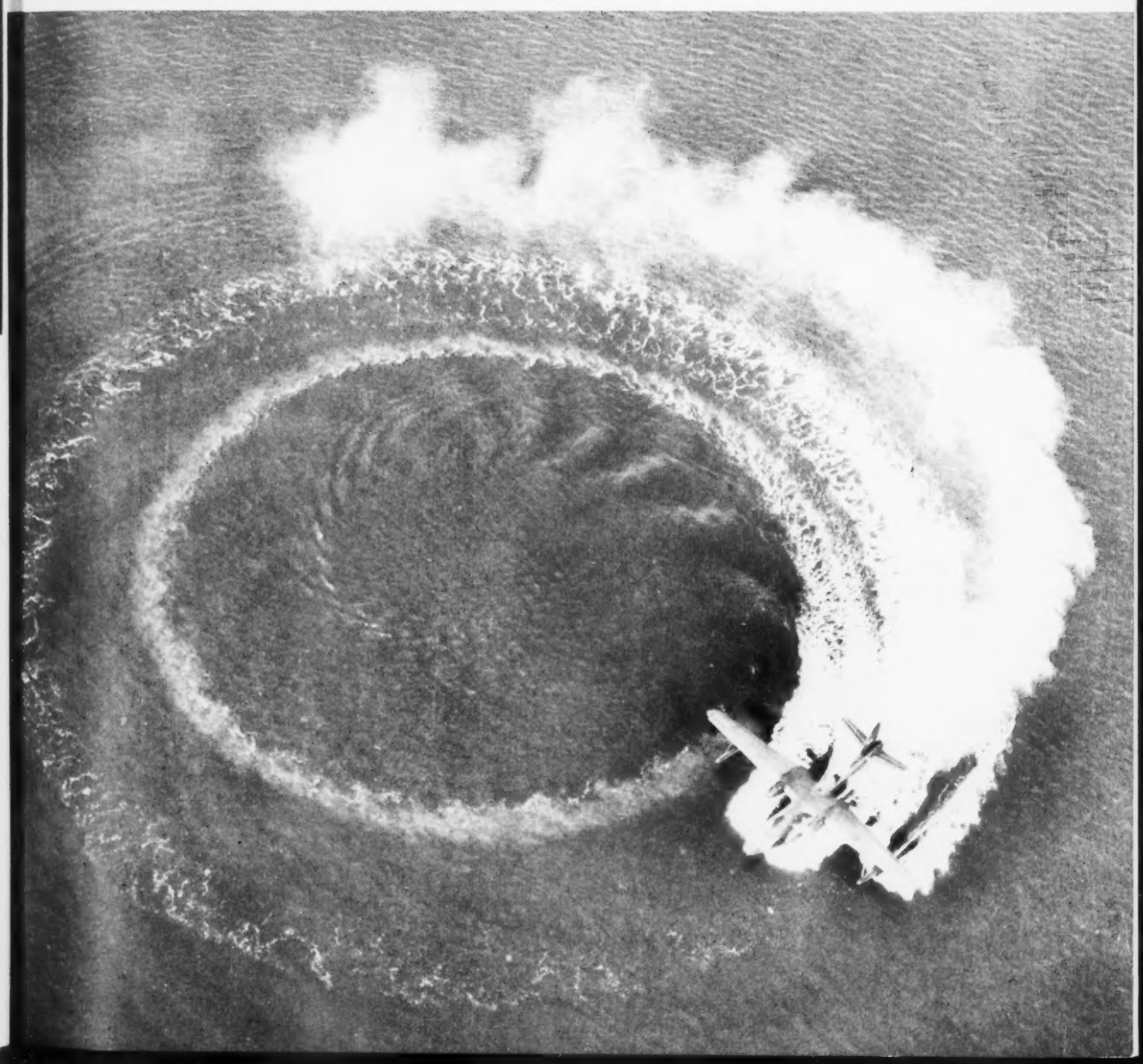
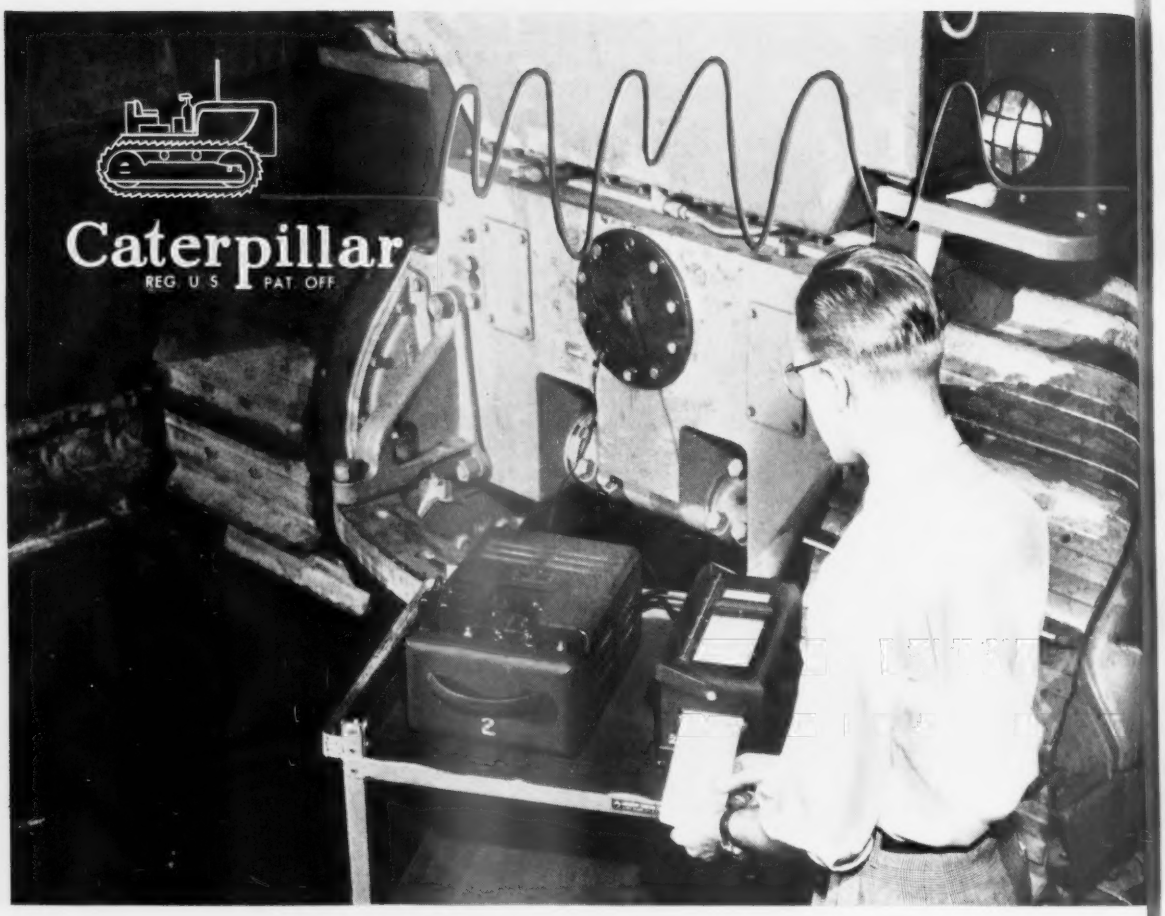
AERONAUTICAL ENGINEERING REVIEW

FEBRUARY 1951





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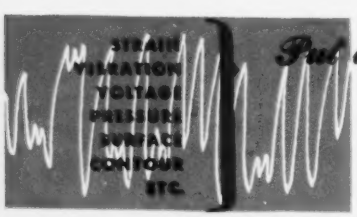

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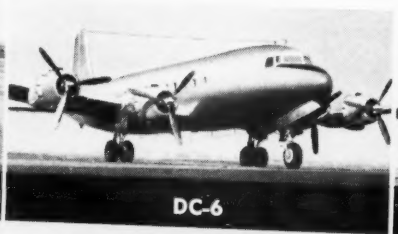

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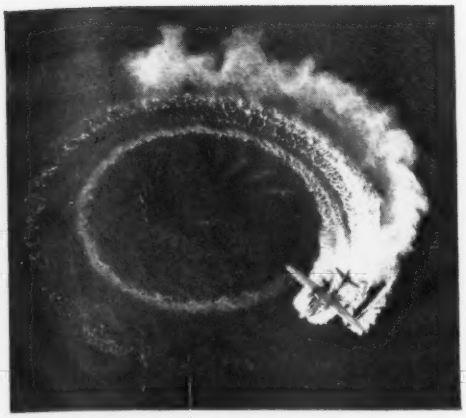

Cover—The XP5M-1 prototype of the Marlin flying boats, built by The Glenn L. Martin Company, demonstrates a short-radius turn through the use of hydroflaps. These hydroflaps are underwater rudders and brakes, developed by Martin engineers, which permit quick turns and fast maneuvering in restricted waters. Operated hydraulically from the cockpit, they are located on each side of the hull near the stern and may be used either separately or together when braking action is desired.

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AERONAUTICAL ENGINEERING REVIEW

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I. A. S. News

A Record of People and Events of Interest to Institute Members

March 16 Set As Date for Sixth National Flight Propulsion Meeting

Cleveland Meeting Will Be Held at N.A.C.A.'s Lewis Flight Propulsion Laboratory

HARD ON THE HEELS of the Nineteenth Annual Meeting of the Institute of the Aeronautical Sciences comes the Sixth National Flight Propulsion Meeting of the I.A.S. Under the sponsorship of the Cleveland-Akron Section, this meeting is scheduled to be held on March 16 in the Auditorium of the Lewis Flight Propulsion Laboratory, N.A.C.A., Cleveland.

John H. Collins, Jr., Assistant Chief of Research, Lewis Flight Propulsion Laboratory, N.A.C.A., and Chairman of the Cleveland-Akron Section, has announced that several interesting themes are being developed by the local Section for presentation at this meeting.

World conditions and the nature of the subject matter have made it necessary that the attendance at the two sessions during the day be restricted to members who are American citizens and who possess active clearance by either the Air Force or Navy to receive confidential information. Institute members will receive a general announcement of the meeting and an application for clearance. Those desiring to attend should return the clearance form as soon as possible to permit adequate time for processing. Also, the size of the group must be limited to the capacity of the Laboratory's Auditorium.

The Registration Fee will cover the cost of transportation by bus from the Hotel Carter to the Laboratory and return, as well as the luncheon to be served at the Laboratory.

No clearance will be required for the evening session of the meeting at the Hotel Carter. The evening program will include a reception and a dinner.

Mr. Collins, as the Cleveland-Akron Section Chairman, will extend the official welcome to the Institute members and guests who will attend this meeting. The other Section Officers and general membership will be on hand, of course, to act as hosts for the visitors.

As a matter of information, the Officers of the Cleveland-Akron Section are: Chairman, Mr. Collins; Vice-Chairman for Akron, Dr. Robert S. Ross, Engineering Specialist in Charge of Special Assignments, Goodyear Aircraft Corporation of The Goodyear Tire & Rubber Company; Vice-Chairman for Cleveland, William A. Fleming, Chief of Altitude Test Chamber Branch of Lewis Flight Propulsion Laboratory, N.A.C.A.; and Secretary-Treasurer, Morris A. Zipkin, Engineering Specialist for Goodyear Aircraft Corporation. The total membership of this section is approximately 218.

The first of these annual meetings, tagged the National Aircraft Propulsion Meeting, was held in Cleveland on March 21, 1946. Approximately 450 members and guests registered on that occasion. Among the topics discussed at this meeting were: "Vapor Lock and Pump Selection in Aircraft Fuel Systems," "Propellers for Aircraft Gas Turbines," and "Aircraft Ejector Performance." Papers dealing with design and practical problems of jet engines and theoretical problems of jet propulsion were also given.

Fourteen papers were presented at the Second Annual Aircraft Propulsion Meeting held in Cleveland on March 28, 1947. They included such subjects as the design of gas turbine components and fuels for gas turbines. The evening symposium was devoted to a discussion of the performance of various types of aircraft propulsion systems by members of the staff of the N.A.C.A. Cleveland Laboratory.

Host at Propulsion Meeting: *The Chairman of the Cleveland-Akron Section, John H. Collins, Jr., will extend an official welcome on behalf of the local Section.*

The Third National Flight Propulsion Meeting was held in Cleveland on March 19, 1948. The three sessions at this meeting covered gas turbine engine problems, a symposium on design problems of turbojet power-plant installations, and performance possibilities of aircraft engines utilizing gas turbines.

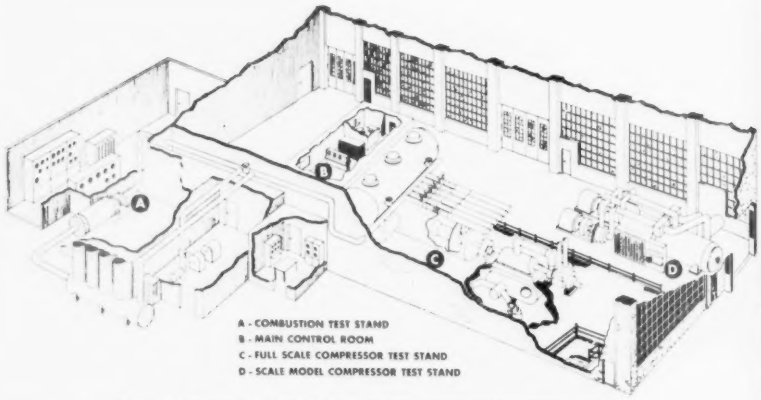
On March 18, 1949, the program of technical sessions for the Fourth National Flight Propulsion Meeting was concerned with aircraft jet-engine compressors and gas turbines, aircraft jet-engine combustion, and aircraft jet-engine thrust augmentation and controls.

A general session touching upon turboprops, modern propeller refinements, rocket-powered missiles, and atomic energy for aircraft was presented at the Fifth Annual Flight Propulsion Meeting on March 24, 1950. Two other sessions included lectures on turbine-powered aircraft and ice protection for gas-turbine-powered aircraft.

G-E Aircraft Gas Turbine Laboratory Dedicated

The Aircraft Gas Turbine Laboratory, General Electric Company, was dedicated on November 14 to the memory and honor of the late Dr. Sanford A. Moss (1872–1946), who not only created the forerunner of modern turbojets 47 years ago but who later won aviation fame as the "father" of the turbosupercharger. The dedication ceremonies were attended by U.S. Air Force and Naval officers, company officials, civic leaders, and representatives of the press.

In his formal address to the assemblage, Major Gen. Donald L. Putt, A.F.I.A.S., Director of Research and Development, U.S.A.F., stated: "The Air Force and G-E now have new developments in the laboratory and on the drafting boards which show promise of performance not considered possible 2 or 3 years ago... This gas turbine laboratory will provide the necessary facilities for the final development and testing of these newer gas turbines."



GENERAL ELECTRIC AIRCRAFT GAS TURBINE LABORATORY, LYNN, MASS.

G-E's LATEST: *The recently dedicated Aircraft Gas Turbine Laboratory in which components of aircraft gas turbine engines will be tested is the most recent addition to the company's multimillion-dollar investment in the aircraft power-plant industry. A schematic drawing of the lab is shown above.*

Dedication Speech

Charles E. Wilson, then President, General Electric Company (now, Director, Office of Defense Mobilization), gave the dedication speech. In it he credited "just ordinary man" with being that "necessary and priceless ingredient" behind the dedication of any new facility. In speaking of the "industrial mosaic" made up of the many individual components going into the completion of a whole, he declared: "The desperate necessities of war are met by almost superhuman effort, and the meeting of them provides a rich bonus for peacetime problems of a different and unexpected sort." In concluding, Mr. Wilson stated: "We are dedicating it [the laboratory] to the memory of a man [Dr. Moss] who to me was typical of all of those talented and determined fighters for a better way and a better life that are found not just in General Electric, by any means, but in all American industry."

Dr. Moss, who was a Fellow of the Institute, was the 1943 recipient of The Sylvanus Albert Reed Award for "the development of the turbosupercharger which has made possible the high-altitude operation of aircraft." He was awarded the 1940 Robert J. Collier Trophy jointly with the Army Air Corps for "outstanding success in high-altitude flying by the development of the turbosupercharger." He also received one of G-E's Coffin awards for his supercharger work. Dr. Moss during his lifetime held 46 patents on superchargers, compressors, and other mechanical devices.

SHOWER BATH: *After the exhaust gases are released from the combustion test stand and are measured for temperature and pressure distribution, the gases pass through this water bath (shown above) in the main exhaust duct. Here the hot air is cooled from 1,800° to below 400° F. before being sent into the silencers at G-E's Aircraft Gas Turbine Laboratory.*

Testing Facilities

The laboratory, begun in 1946, is the latest addition to the multimillion-dollar aircraft gas-turbine test, development, and production center at the River Works, Lynn, Mass. It is a components testing laboratory with facilities for full-scale and scale-model testing of compressors and combustion systems. Turbine testing, both scale-model and full-scale, at present is conducted elsewhere in the center. The laboratory building is 250 ft. long and 120 ft. wide.

Compressors Tested

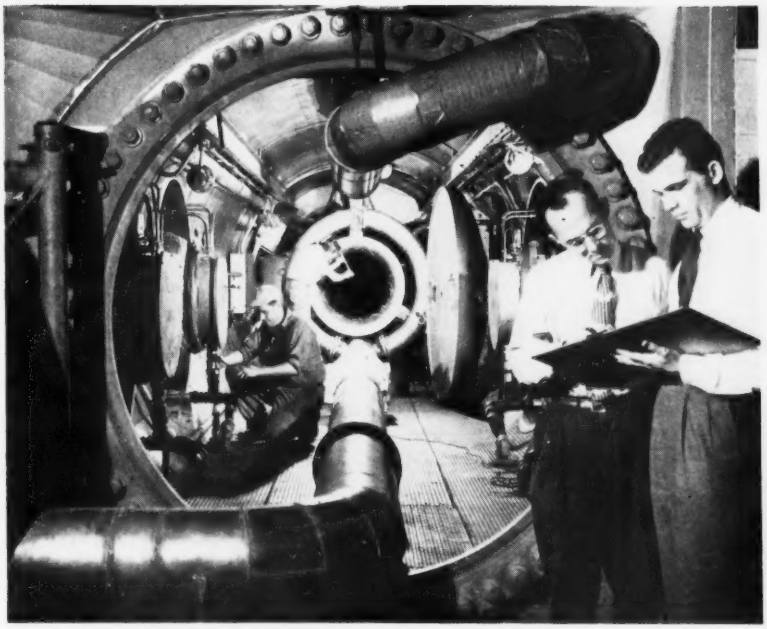
The heart of the laboratory is the 40-by 10-ft. cylindrical steel tank in which experimental compressors for future engines are tested. The tank is insulated on the compressor inlet side with eight layers of polished aluminum sheets.

The high-temperature, high-pressure discharge section is insulated on the outside with 4-in. layers of glass wool. The compressor test stand operates either closed or open cycle, and airflows of 320 lbs. per sec. can be handled. Altitudes up to 70,000 ft. can be simulated, and temperatures ranging from −100° to +100°F. can be attained. Present plans call for additional equipment that will permit temperatures of 200°F.

Compressor performance under simulated flight conditions approaching Mach Number 1 can also be investigated.

Control Room

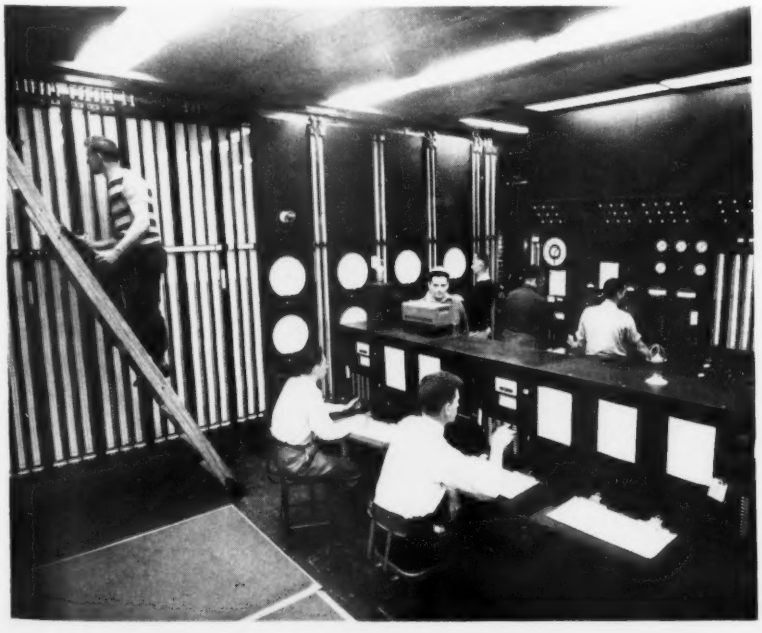
In the main control room, air-conditioned and sound-insulated, readings are taken from more than 700 different instruments during the course of a single test. All airflows and temperatures are measured in triplicate. Some of the other recordings include air pressures, torque, blade strain, vibration, and blade clearance. There are 250 control valves alone. Warning lights and horns caution operators when pressures and temperatures are above or below permissible limits in the various systems.



TESTING FACILITY: *The largest of the new G-E Aircraft Gas Turbine Laboratory's test stands is the full-scale compressor test stand (shown above). Altitudes up to 70,000 ft. can be simulated, and temperatures can be varied from −100° to +100° F. Two steam turbines operating in tandem, with a maximum power output of 40,000 hp., serve as the prime mover for its operation.*

More than 30 men take readings and check on the equipment. Equipment operators on the main floor and in the basement receive instructions from the control room over sound-powered "intercom" sets. Semihourly readings are relayed to a central recording station.

INSTRUMENTATION: *In the main control room (shown above), a score of men record the compressor performance by taking readings from more than 700 different instruments during the course of a single test in G-E's Aircraft Gas Turbine Laboratory.*



Combustion Test Stand

The combustion test stand can be cut in directly on the closed-cycle system and can be supplied with air discharged by the test compressor. It can burn fuel at the rate of 50,000 lbs. per hour and permits operation of complete combustion assemblies over a range of pressures from sea-level atmospheric to 250 lbs. per sq.in. The exhaust gases are measured for temperature and pressure distribution after the gases are released from the combustion chamber. These gases are then passed through a water "bath" to lower the temperatures from 1,800° to below 400°F. before being discharged through 50-ft. pipes to four Maxim silencers located outside the building. Once the exhaust enters efferent pipes, or air ducts, it expands and loses velocity. The silencers complete the job of controlling the deafening noise resulting from the operation of the test stands and send the gases into the sky.

The Future

Looking toward the future, this laboratory, devoted to fundamental research, will be a testing ground for new conceptions in turbine power plants; or, in the words of Charles E. Wilson: "We expect science and technology to keep pounding away at our horizons; we expect them to shoot for the moon. . . The eyes of most of us are constantly directed to the dazzling, unknown future."

(Top) A portion of the collection, devoted to experiments carried on at Auburn between 1918 and 1929.

(Below) General view showing approximately half of the exhibit. Full-size rocket in the foreground is type used in experiments of 1936–1938.

The Robert H. Goddard

The Robert H. Goddard Memorial Exhibit, made possible through the donation by Mrs. Esther C. Goddard of the library and apparatus used by her late husband, has now been established as a permanent part of the Aeronautical Archives of the Institute.

To mark the opening of the exhibit on December 1, 1950, a buffet luncheon and reception was held at the Institute building, at which time Mrs. Goddard officially turned over the

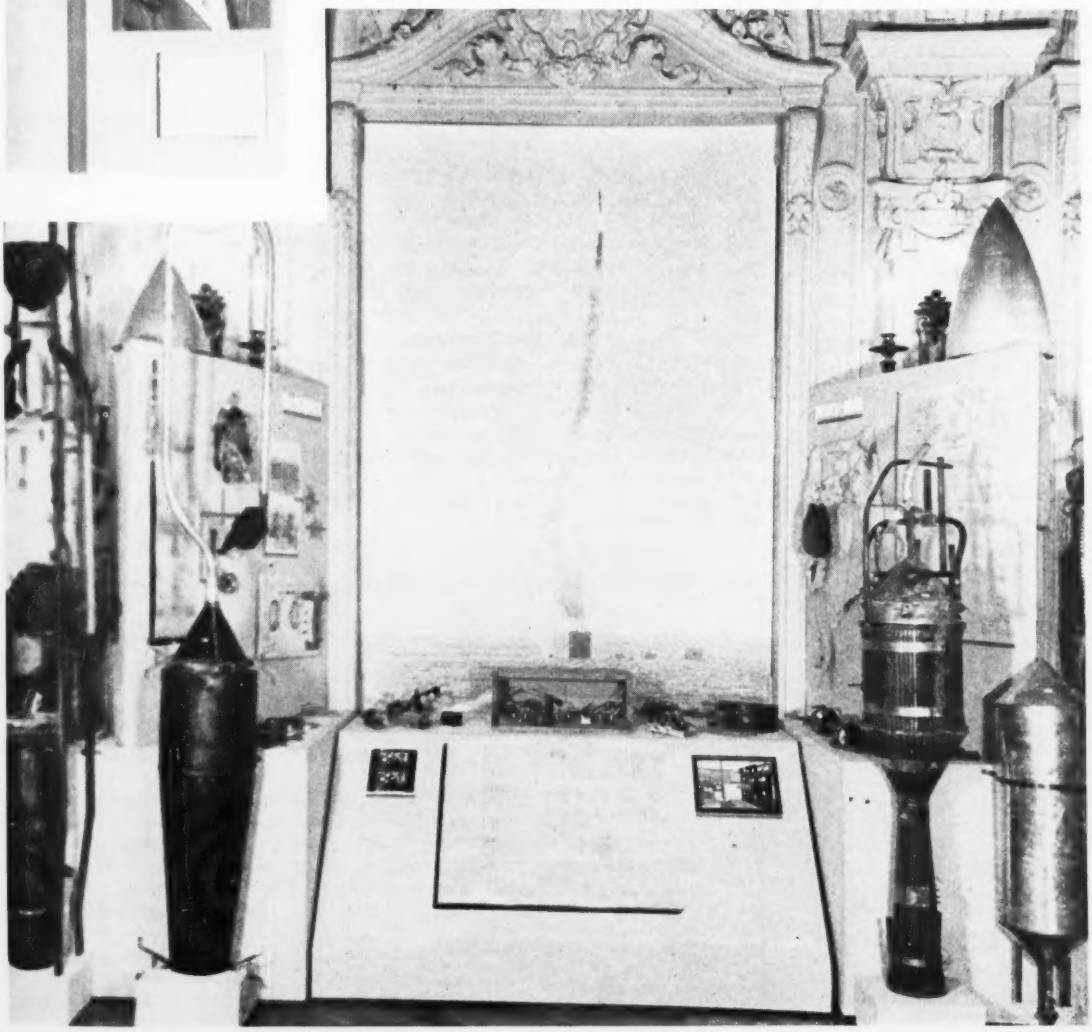
Memorial Exhibit

exhibit to the I.A.S. The reception was attended by friends and admirers of Dr. and Mrs. Goddard, some of whom had worked with Dr. Goddard. A number of members of the American Rocket Society and members of the I.A.S. staff were also present.

The Robert H. Goddard Memorial Exhibit, as well as the rest of the Aeronautical Museum, is open to the public from 10:00 to 4:00 on weekdays.

(Top) This panel illustrates the fact that the German V-2's incorporated many of Dr. Goddard's ideas and inventions.

(Below) Centered around a picture of the successful L-14 launching, in 1937, are displayed items connected with Goddard's work at Roswell, N.M., 1930–1941.



Helicopter Society News

*Activities and Events of Interest to A.H.S. Members**

THE FIRST 1950–1951 EASTERN REGION MEETING of the American Helicopter Society, held recently at the Engineers' Club, Philadelphia, heard Clarence Belinn, President of Los Angeles Airways—America's pioneer helicopter air-mail service—declare the helicopter as "the logical answer now, and in the near future, in solving the short-haul passenger problem. . . ."

"The helicopter," Belinn told the 130 A.H.S. members and nonmembers at the dinner meeting, "is the only vehicle that can serve the 'forgotten area.'"

Mr. Belinn then described the "forgotten area" as a "time corridor about 2 hours wide" or a "point-to-point distance of about 200 miles."

He added that surveys he has made would indicate that about 67 per cent of all future air traffic will take place within this short-haul area.

"At present we serve about 5,000,000 people in the Los Angeles area and move about one-third of the mail in the area we cover," he said. "Our records show that better than 74 per cent of the mail we carry is expedited 17 to 24 hours."

Pointing out that passenger service via the helicopter is near—both in New York and in Los Angeles—Mr. Belinn predicted that, in 10 years (if the military demands do not take up the output of helicopters), the helicopter would be self-sufficient, without the need for Post Office mail subsidies, carrying passengers up to the 200-mile mark.

After 3 years of operation, Mr. Belinn is now convinced that the rooftop landing is most desirable for helicopter operations.

"We've made our initial step in this respect," he said, "in getting the Pacific Mutual Life Insurance Company to plan the building of a 200-ft. square rooftop heliport on their new building in the heart of Los Angeles." He also added that a long-range airport-planning program in California has been recently changed to heliport planning.

The big advantage of the rooftop heliport, he told the A.H.S., is that it is permanent and does not "lose out to the encroachment of real-estate expansion, change of zoning laws, and other obvious factors."

He admitted that the helicopter operating in thickly settled areas is "still a nuisance" but that it is tolerated because it has been accepted as a public necessity. "However," Mr. Belinn added, "we've got to think ahead and be prepared for operation into center of the cities, and the answer then is operation from rooftops."

Looking into the future, Mr. Belinn gave, as his opinion, that the successful passenger-carrying helicopter would be in the category of something "like the Lockheed Electra—with two engines, able to carry ten or more passengers, about a 12,000-lb. aircraft, and with particular emphasis on the blades so that if one is damaged or lost the 'copter is still under control and operable.

"Actually, right now, for commercial operation," he continued, "we've got to build helicopters that are simpler and require less maintenance and fewer modifications. We're making progress in other ways, particularly in instrument flight."

Steve Tremper, Eastern Region Vice-President of A.H.S., arranged the successful meeting, which brought A.H.S. members from outside the Philadelphia area, including Robert Hellisen, of the New York Port Authority; representatives of C.A.A.; Major A. DeLalio and Comdr. Frank Erickson, Naval Air Test Center, Patuxent River, Md.

Frank N. Piasecki, President of A.H.S., opened the meeting and welcomed the members.

▸ **Pre-Forum Meeting**—A meeting of members and officers of the American Helicopter Society was held recently in the Morton, Pa., office of Frank N. Piasecki, President of A.H.S., at which it was voted to consider holding the Seventh Annual Helicopter Forum in Washington in 1951.

In deciding to break away from the precedence of having the Forums in Philadelphia, it was felt that greater national attention would be focused both upon the Forum and the helicopter in general with the transfer to the Nation's Capital.

It was also agreed that the Military Services would be invited by A.H.S. to hold a demonstration of helicopter flying, using the latest models, and that the Smithsonian Institution would be requested to provide static displays.

Mr. Piasecki agreed to name committee chairmen to work out the additional details for the Forum in Washington and the Military participation.

It is tentatively planned to have the Forum during the latter part of April.

Those present at the meeting were: Frank N. Piasecki, President; T. R. Pierpoint, Secretary; R. B. Lightfoot, New England Region Vice-President; H. S. Tremper, Eastern Region Vice-President; R. Allen Price, Great Lakes Region Vice-President; Bartram Kelley, Technical Chairman; J. E. Beighle, Membership Chairman; E. J. Huber, Publicity Chairman; and Mary Morgan, Secretarial Assistant.

Others at the meeting included: Monroe Brown, Lloyd G. Curtis, Elliot Daland, C. W. Lefever, Don Ryan Mockler, H. J. Mulvey, R. H. Prewitt, V. Roxor Short, Paul H. Stanley, Burke Wilford, and Paul Thomas.

E. J. HUBER

Tentative Plans for Seventh Annual Forum

Latest word that has been received on the plans for the Seventh Annual Helicopter Forum indicate that April 26, 27, and 28 are the dates to set aside. The procedures of the last few years will probably be followed, with two days of lectures and the third day for the possible flying exhibits.

Bartram Kelley has accepted the job as General Chairman of the Forum, and chairmen of the subcommittees are being chosen. They will take care of the different phases of the Forum, such as planning the sessions, selecting and inviting the guest speakers, registration, and publicity. There will also be a committee formed to take care of the formulation and publishing of the Forum *Proceedings*.

As soon as the details are settled, a notice will be sent to all members of the Society.

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* In accordance with the cooperative management agreement between the I.A.S. and A.H.S. announced last April, the REVIEW will be the medium through which A.H.S. news items are published. Columns devoted to such items will appear from time to time in this section of the magazine as they are received.—ED.

Dr. Theodore von Kármán.

von Kármán Wins British Medal

The presidents of the eight major engineering societies of the United Kingdom have selected Dr. Theodore von Kármán, H.F.I.A.S., as this year's recipient of the Kelvin Gold Medal. Awarded every 3 years for outstanding contributions to engineering science, this medal commemorates the achievements in this field of Lord William Thomson Kelvin (1824–1907), British mathematician and physicist. This medal was first awarded in 1920; however, it was not presented between 1938 and 1947.

Among the eight scientists who have received the medal are Guglielmo Marconi of wireless fame; the late Nobel Laureate physicist, J. J. Thomson; and Sir Frank Whittle, creator of the first turbojet engine. Dr. von Kármán is the second American to be entered on the list of Kelvin medalists, the first being Elihu Thomson, famous pioneer of electrical engineering in the United States, who won the award in 1923.

As is a well-known fact, Dr. von Kármán has been accorded honors by many countries. Briefly stated, these honors include six honorary degrees (four from European universities and two from American universities) and numerous awards, such as the 1941 A.S.M.E. Gold Medal, The Sylvanus Albert Reed Award for 1941 from the Institute, the John Fritz Medal for 1947, the 1948 Franklin Medal, and the U.S. Medal of Merit in 1946. He is an honored member of more than a score of scientific societies, in addition to being an Officer in the French Legion of Honor.

Dr. von Kármán is presently Honorary Professor, Columbia University, and Chief Consultant to the Aerojet Engineering Corporation, which he founded in 1942. He is also Chief Scientific Advisor to the Arnold Engineering Development Center of the United States Air Force and Chairman of the Scientific Advisory Board, U.S.A.F.

Lear Wins Collier Trophy

On December 15, William P. Lear, Chairman of the Board and Director of Research and Development of Lear, Incorporated, was awarded the National Aeronautic Association's Robert J. Collier Trophy for 1949 by the President of the United States. The citation read: "For his outstanding achievement in the development, perfection, application, and production of the Lear F-5 Automatic Pilot and Automatic Approach Control Coupler System which makes possible the safe landing of jet aircraft regardless of extreme weather or visibility conditions."

The F-5 Automatic Pilot and Automatic Approach Control Coupler System, developed by Lear, Incorporated, under the leadership of Mr. Lear and under the auspices of the All-Weather Flying Division of the Air Materiel Command, is the first such device to be accepted for use in jet fighter aircraft. The Air Force has awarded the company multimillion dollar contracts for the production of this system. The importance of this new development, the culmination of 6-years' experimentation, can be appreciated by the known difficulty of flying jets on instruments and the improbability of landing them in closed-weather conditions.

This electromechanical device automatically holds an aircraft on any predetermined course at any altitude and also permits the pilot to alter this course at will. Although the F-5 is 1 cu.ft. in size and 36 lbs. in weight, the 48-year-old Mr. Lear claims that the Lear Automatic Pilot will fly anything from a Bonanza to a B-36.

Mr. Lear, an Associate Fellow of the Institute, has invented and designed many necessary and useful items in the fields of electronics, mechanics, radio, sound, and aviation. His initial invention was what is said to have been the first practical automobile radio; it was ultimately sold to Motorola. In 1940, William Lear was presented with the Frank M. Hawks Memorial Award for the design of the Learmatic Navigator.

Victor E. Carbonara.

Square D Company's Kollsman Division Sold; Victor E. Carbonara To Be President

F. W. Magin, A.M.I.A.S., and Glen E. Swanson, presidents of Square D Company and Standard Coil Products Company, Inc., respectively, have announced that Standard Coil Products has acquired Square D's Kollsman Division.

Although the terms of the contract were not announced, the purchase price was said to be in the neighborhood of $5,000,000. This includes the Kollsman plants and other physical assets,

William P. Lear, 1949 Collier Trophy Winner.

Here it is. One of the most compact aircraft actuators meeting all military requirements—the ROTORette, adopted for application on the F-84E, F-84F and F-94C. It is ideally suited for valve or damper operation. Compactness and light weight (little more than one pound) make its use mandatory where space or balance is critical.

Limit switches are load sensitive and adjustable for any value up to 50 pound-inches. Motion between travel limits is controlled by *externally adjustable* positive stops, causing a reaction on the load limit switches.

Operating on 26 volts D.C., the ROTORette is available in two models, one of which can incorporate either a position-indicating potentiometer or an intermediate position switch. Both models are qualified for compliance to Specifications AN-M-40 (Motor and Brake, including Filter), USAF-41065 (Environmental for complete actuator), and USAF-41251 (General Electro-Mechanical Actuator Specification).

Write for Bulletin 118.

AIRBORNE
ACCESSORIES CORPORATION
Note our new address ➧ 1414 CHESTNUT AVENUE HILLSIDE 5, NEW JERSEY
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located in the Elmhurst district of New York City, as well as its good will, patents, research, and development. The engineering laboratories and plants occupy an area of over 200,000 sq.ft.

Victor E. Carbonara, A.F.I.A.S., who has been Square D's Vice-President in Charge of the Kollsman Instrument Division and General Manager of Kollsman since about 1940, is now President of the new concern.

Mr. Carbonara was employed by Pioneer Instrument Company in 1925 as a Draftsman. Within a year's time, he was promoted to Assistant Chief Engineer, and by 1927 he was Chief Product Engineer. In 1934, he became identified with Kollsman Instrument Company in the capacities of Chief Engineer and Factory Manager. Then, when Kollsman was taken over by Square D, he was made an executive of that firm.

Mr. Carbonara was born in Sardinia and received the degree of Master Mariner from the Nautical Institute in Genoa, Italy. Two years after matriculating at the Scuola Superiore Navale, Genoa, for Naval Architects and Mechanical Engineers, he was drafted and sent to the Italian Royal Naval Academy, Leghorn, from which he was graduated in 1916. He left the Italian Navy in 1920 and attended the Scuola Superiore di Commercio prior to emigrating to the United States in 1921.

During his professional career, Mr. Carbonara has invented various special processes and innumerable aircraft instruments. He has delivered many lectures and has written many articles. Among a listing of his hobbies are found mycology, microscopy, photography, astronomy, telescope making, horology, cabinet working, painting, music, etc.

Mr. Carbonara is a past-member of the I.A.S. Council, having served from 1947 to 1949.

A.I.A.A. Elects I.A.S. Members to Posts

Three Institute members have been elected to serve in official capacities in the Eastern and Western regions of the Aircraft Manufacturers Council, Aircraft Industries Association of America, Inc.

Lawrence D. Bell, I.A.S. Founder and Associate Member, President of Bell Aircraft Corporation, was elected to serve as Vice-Chairman of the Eastern Region.

Donald W. Douglas, I.A.S. Founder and Past-President, Honorary Fellow, and Benefactor, who is President of Douglas Aircraft Company, Inc., has been elected Chairman of the Aircraft Manufacturers Council's Western Region. Robert E. Gross (A.M.), President and Chairman of the Board, Lock-

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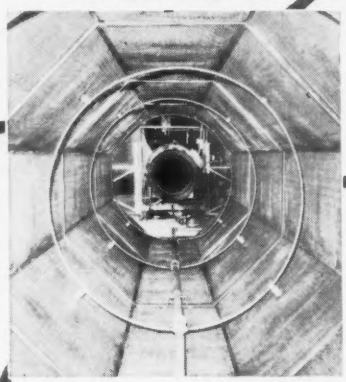
Ends ANNOYANCE, COMPLAINTS, THREATS of LEGAL ACTION due to disturbing
NOISE



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JET AIRCRAFT MUFFLERS AND PANELS

cut the roar of jets to the level of surrounding neighborhood noises.

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45 Granby St., Hartford, Conn.
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Flying hospitals for evacuating the wounded . . . swift troop transports . . . or giant all-purpose cargo carriers—new airplanes such as the Douglas C-118A bring new versatility to the Military Air Transport Service. The C-118A, soon to be in service, is the Air Force designation for the DC-6A *Liftmaster*—a larger version of the famous DC-6 passenger transport. Flying payloads up to 30,000 lbs. at 320 mph with a range of about 1,740 miles, the C-118A will do *one-third more work* than the C-54 at *one-third less operating cost!* Thus Douglas answers the need for a high-speed, long-range *dependable* military air transport. Meanwhile, on the drafting board and in the laboratory, Douglas engineers and research experts continue to pioneer new and more advanced aircraft in the direction of turbo-prop, jet and rocket propulsion.

Douglas Aircraft Company, Inc.

Depend on

DOUGLAS

WORLD'S LARGEST BUILDER OF AIRCRAFT FOR 30 YEARS ▲ MILITARY AND COMMERCIAL TRANSPORTS
FIGHTERS ▲ ATTACK PLANES ▲ BOMBERS ▲ GUIDED MISSILES ▲ ELECTRONIC EQUIPMENT ▲ RESEARCH

heed Aircraft Corporation, was elected Vice-Chairman of the Western Region.

The terms of office are for the 1951 calendar year.

Three Student Members Win Contest

Donald R. Lapworth, Student Branch Member, University of Detroit, won first place in the annual Continental Airplane Design Contest, while Student Members Bernard R. Martus and Vernald J. Smith were awarded second and third places, respectively. Mr. Lapworth received a personal trophy and $125 in cash.

The contest, open to all Aeronautical Engineering students in the University with the proviso that they use a Continental Aircraft Engine in the design, was judged on the basis of 75 per cent design score and 25 per cent the student's scholastic rating. The design rating was based 20 per cent on theoretical calculations; 45 per cent on airplane arrangement, structural feasibility, and engineering soundness; 20 per cent on ingenuity; and 15 per cent on overall neatness.

Judging the contest were Peter Altman, A.F.I.A.S., Vice-President, Continental Motors Corporation; Melvin Holderness, General Manager, Aero Activities, Inc.; and Dr. Frederick W. Ross, M.I.A.S., Professor of Aeronautical Engineering, University of Detroit

In addition to placing first in the Continental Airplane Design Contest, Mr. Lapworth also won the annual Citizenship and Scholarship Award, sponsored by the American Legion Aviation Post No. 257. This award is based on 50 per cent citizenship and 50 per cent scholarship and is open to all Senior Aeronautical Engineering students.

Necrology

Carroll M. Aument.

Carroll M. Aument

Carroll M. Aument, A.F.I.A.S., passed away on November 25 after an illness of approximately 2 months.

Mr. Aument, who was born in Strasburg, Pa., on March 7, 1888, was a mechanical engineering graduate of Drexel Institute. From 1909 to 1928, he was associated with the automotive industry, first as Technical Mechanic; later as Tester, Draftsman, and Designer; and, finally, as Experimental Engineer on the Chadwick, Pullman, and Brewster automobiles and the Mack Truck products.

Mr. Aument was first identified with the aviation trade in 1928 when he became factory manager of the Fokker Aircraft Corporation of America. From there he went, in 1930, to American Airlines, Inc., as Division Manager in charge of engineering, testing, and overhaul of airplanes and engines. Two years later, he joined the staff of The Glenn L. Martin Company as Designing Engineer on clippers and army bombers.

In 1935, Mr. Aument became Assistant Engineer with Sikorsky Aircraft Division, United Aircraft Corporation. His first work at Sikorsky was concerned with new proposals for flying boats. He did torpedo, bomb, and machine-gun installation design on the XPBS-1 four-engined flying boat and was then transferred to Chance Vought Aircraft Division, United Aircraft, to do the bomb bays on the XPBS-1.

After returning to Sikorsky, Mr. Aument was placed in charge of all revisions on the S-43 twin-engined flying boats. On the VS-44A four-engined flying boats, he was responsible for the design and installation of the main power plants, flight deck, auxiliary power plant, automatic pilot, deicers, anti-icers, etc. He also did the design work on the original Sikorsky helicopter, the VS-300. Subsequently, he was in charge of all vendors contracts that pertained to technical matters, as well as the improvement and simplification of production design with regard to lowered manufacturing costs. This particular work covered the R-4B, R-5, and R-6 Sikorsky helicopters.

For several years prior to his death, Mr. Aument was Sales Engineer at the Kenneth F. Thomas Company.

Walter H. Beech

Walter Herschel Beech, M.I.A.S., President and Chairman of the Board of Beech Aircraft Corporation, passed away on the evening of November 29 from a heart attack.

Born on a farm near Pulaski, Tenn., on January 30, 1891, Walter Beech made his first solo flight approximately 23 years later (in 1914) on a Curtiss pusher biplane. When the United States entered World War I, he enlisted in the Aviation Section of the U.S. Army Signal Corps and for the next 3 years served as pilot, flight instructor, and

Walter H. Beech.

engineer. After his discharge from the service, he barnstormed around the countryside for a time before joining the Swallow Airplane Company in 1922 as Test Pilot and Sales Representative. The following year, he was promoted to General Manager at Swallow, but in 1925 he resigned to help found the Travel Air Manufacturing Corporation. One of the outstanding airplanes to be designed by this concern was the Travel Air Mystery Ship, introduced in 1929 and produced in 1930. The "Mystery S" was a single-place, low-wing, open-cockpit monoplane powered with a Wright Whirlwind 300 engine and capable of speeds in excess of 200 m.p.h. This ship won the 1929 Thompson Trophy Race and later carried Capt. Frank Hawks to new transcontinental and other speed records.

In 1930, a merger was completed between the Travel Air interests and Curtiss-Wright Corporation. Mr. Beech, who had formerly been Travel Air's President, stayed on as President of Curtiss-Wright Airplane Company

and Vice-President of Curtiss-Wright Corporation. He left Curtiss-Wright in 1932 to form the Beech Aircraft Company, which in 1936 was succeeded by Beech Aircraft Corporation. He startled the aircraft industry by introducing the Beechcraft cabin biplane with negatively staggered wings and fully retractable landing gear. World War II saw the factory operating on a full wartime production basis, manufacturing among others the AT-7, AT-10, AT-11, and C-45. The Bonanza is one of their more recent products.

Walter Beech is credited with designing the first commercial airplane with a completely faired-in, air-cooled motor, as well as the airplane that won the Dole prize in 1927 for the first successful flight from the United States mainland to Hawaii. During his lifetime, Mr. Beech, himself, participated in many air races, derbies, etc. One of them, the Ford Reliability Tour, which he won, provided one of the first practical demonstrations of instrument flying in the United States.

Mr. Beech, a Founder Member of the Institute, was also a member of the I.A.S. Advisory Committee.

He is survived by his widow, the former Olive Ann Mellor, and his two daughters, Suzanna and Mary Lynn.

William P. Harrigan

William Patrick Harrigan, T.M.-I.A.S., died recently at the age of 30.

Upon his graduation in 1942 from the University of Minneapolis with an aeronautical engineering degree, Mr. Harrigan became Flight Test Engineer at the Airplane Division, Curtiss-Wright Corporation. At the time of his death, he was Engineering Test Pilot at Chance Vought Aircraft Division, United Aircraft Corporation. He held C.A.A. Commercial Pilot Certificate No. 27331-40.

Charles C. Love

Charles Cooke Love, T.M.I.A.S., was killed in an automobile accident last September 10. He was 29 years old.

Mr. Love attended the University of Maryland and was graduated in 1943 with a B.S. degree in Mechanical Engineering. His first employment was with Douglas Aircraft Company, Inc., first as Engineering Draftsman "B" and then as Stress Analyst "B." At the time of his death he was Stress Analyst "B" with North American Aviation, Inc.

Major G. McAlpine

Gustavus McAlpine, Major, R.A.F. (Ret.), died this past April in England at the age of 69.

Since his graduation from Durham College of Science in England, Major McAlpine was employed in the capacities of Construction Engineer, Power Engineer, and Electrical Advisor. From 1933 until the time of his death, he was Technical Advisor to the British firm of Kelvin, Bottomley, & Baird.

A Member of the Institute, Major McAlpine was also a member of the Institution of Electrical Engineers and an Associate Fellow of The Royal Aeronautical Society.

Major McAlpine is survived by his widow, Mrs. Violet McAlpine.

James A. Phillips, Jr.

James A. Phillips, Jr., A.M.I.A.S., died recently at the age of 49.

Mr. Phillips was graduated from Yale University in 1925 with a Ph.B. degree. Becoming vitally interested in Aviation in 1934, he was first associated in the aeronautical line with the Security National Aircraft Corporation as Vice-President and Director. A few years later, he was one of the founders of Phillips Aviation Company, of which he was President and General Manager. Mr. Phillips held C.A.A. Private Pilot Certificate No. 33380.

News of Members

▸ **Lawrence D. Bell** (A.M.), President, Bell Aircraft Corporation, was awarded the decoration of the Legion of Honor with the rank of Chevalier by the French Government. It was formally conferred upon him at a dinner on December 5. Mr. Bell's notification of the decree read that the decoration was made "as a token of gratitude for the outstanding services you have rendered to the progress of aeronautical sciences and to the cause of Franco-American friendship by the help you gave to the rehabilitation of the French Air Force."

RETIRES

Major J. Vivian Holman (M.) has relinquished all his executive posts, etc., with Radio & Television Trust Ltd., and its subsidiary companies, as of October 31, 1950. Major Holman has been connected with the aircraft industry for over 30 years. He is a member of the Council of the Air League of the British Empire; is an honorary member of the Council of the London Chamber of Commerce and Chairman of the Joint Air Transport Committee of the Association of British Chambers of Commerce and the Federation of British Industries; and serves on other committees connected with civil aviation. He is a director of Bryans Aeroquipment Ltd., Philco (Overseas) Ltd., and Philco (Great Britain) Ltd. He is an Associate Fellow of The Royal Aeronautical Society.

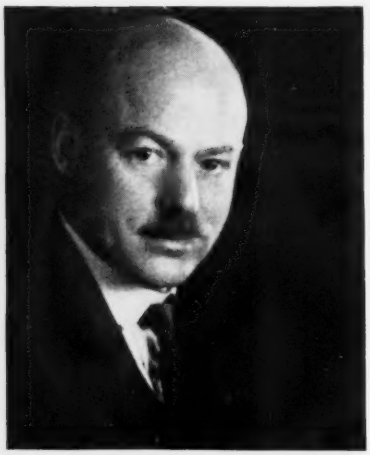
▸ **James H. "Dutch" Kindelberger** (F.), I.A.S. Past-President, Chairman of the Board, North American Aviation, Inc., was awarded the Alumni Merit Award Certificate by the Alumni Federation of the Carnegie Institute of Technology in recognition of his achievements in the aviation industry "which have brought credit to him and to his Alma Mater."

▸ **Frederick B. Lee** (M.), Deputy Administrator, C.A.A., has been appointed a member of the Committee on Navigation, Research and Development Board, Department of Defense, to represent the Department of Commerce.

▸ **Irving Rappaport** (T.M.), who was graduated from the New York Law School cum laude last June, was admitted to the New York State Bar on December 4.

▸ **Richard E. Stockwell** (A.M.), Editor, *Aviation Age*, was one of the winners in the Technical Class category of the Mid-Century Aviation Writing and Picture Competition sponsored by Trans World Airlines. He was awarded a $100 cash prize and a commemorative plaque for the best operation and development story. For being named sweepstakes winner in this class, he was given an extra $100 prize.

▸ **H. Oliver West** (A.F.), President, Canadair, Ltd., has been granted a leave of absence by the company.



HONORED BY BRITISH COLLEGE

Dr. Jerome C. Hunsaker, Founder, I.A.S. Past-President, Honorary Fellow, and I.A.S. Advisory Committee member, was elected an Honorary Fellow of the Imperial College of Science and Technology by the Governors of the College. The citation included reference to "the leading part taken by Professor Hunsaker in the establishment of the friendly alliance between the Massachusetts Institute of Technology and the Imperial College of Science and Technology." Dr. Hunsaker is Head of the Department of Aeronautical Engineering, M.I.T.

Members on the Move

This section has been instituted to give information on the latest affiliations of I.A.S. members. All members are urged to notify the News Editor of changes as soon as they occur.

Elisha R. Baker (T.M.), Project Engineer, Bell Aircraft Corporation. Formerly, Assistant Missile Coordinator, Bell Aircraft.

Dr. William F. Ballhaus (A.F.), Chief, Preliminary Design, Fort Worth Division, Consolidated Vultee Aircraft Corporation. Formerly, Design Specialist and Project Engineer, Douglas Aircraft Company, Inc.

Dr. Jagannath P. Chawla (M.), Engineer, Hughes Aircraft Company. Formerly, Department of Aeronautics, Engineering and Applied Mechanics, Polytechnic Institute of Brooklyn.

Prescott S. Cole (A.M.), Laboratory Metallurgist, American Steel & Wire Company. Formerly, Kaiser Aluminum.

Arthur P. Coletta (T.M.), Junior Research Engineer, Republic Aviation Corporation. Formerly, Student.

Laurance H. Cooper (A.M.), Engineering Consultant. Formerly, Vice-President and General Manager, Pacific Airmotive Corporation.

Robert C. Donovan (A.F.), Chief of Design, Chance Vought Aircraft Division, United Aircraft Corporation. Formerly, Project Engineer, Douglas Aircraft Company, Inc.

Lloyd L. Drury (T.M.), Development Engineer, Aeronautics and Ordnance Systems Division, Ordnance Guided Missile Center, Redstone Arsenal, Ala. Formerly, Test Engineer, Test Division, General Electric Company.

Murray I. Edelstein (M.), Missile Flight Test Instrumentation Engineer, Consolidated Vultee Aircraft Corporation. Formerly, Senior Flight Test Engineer, Curtiss-Wright Corporation.

First Lieutenant Jerome O. Feldman (T.M.), now Project Engineer, Photographic Laboratory, Mapping and Charting Branch, Headquarters Air Materiel Command, Wright-Patterson Air Force Base, Dayton, Ohio.

Jerry J. Feldman (T.M.), now Purchase Planner, McDonnell Aircraft Corporation.

William H. Graham, Jr. (M.), Aviation Editor, *The Journal of Commerce*, New York City. Formerly, Editor and Engineering Analyst, American Power Jet Company.

N. E. Halaby, Jr. (M.), Assistant for International Security Affairs, Economic Cooperation Administration. Formerly, Director, Office of Foreign Military Affairs, Department of Defense.

Lieutenant Kenneth W. Hendricks, U.S.A.F. (T.M.), Flight Engineer, Chanute Air Force Base, Ill. Formerly, Engineering Draftsman "B," Consolidated Vultee Aircraft Corporation.

Edmund Israel (M.), Mechanical Engineer, Given Manufacturing Company. Formerly, Design Engineer, Northrop Aircraft, Inc.

John W. Kaczanowicz (T.M.), Aeronautical Engineer, Army Ordnance, Army Aircraft Section, Field Service Division, Maintenance Branch, The Pentagon, Washington, D.C. Formerly, Flight Test Engineer, Flight Test Division, Naval Air Test Center, Patuxent River, Md.

Harold R. Larsen (M.), Servo-Mechanisms, Inc. Formerly, Chief Engineer, W. & L. E. Gurley.

Fredrik-Christian Lassen (T.M.), now Engineer, Samordningsdirektoratet, Ministry of Defence, Oslo, Norway.

Vincent J. Menier (T.M.), Sales Engineer, Westinghouse Electric Corporation. Formerly, 2nd Lt., Pilot, Flight Test, Randolph Air Force Base, Tex.

Edward S. Miller (T.M.), Republic Aviation Corporation. Formerly, Flight Test Engineer, Chase Aircraft Company, Inc.

Kenneth R. Miller (T.M.), Design Engineer—Senior, Consolidated Vultee Aircraft Corporation. Formerly, Electric Design Group Leader, Chase Aircraft Company, Inc.

NAMED BY BENDIX

Arthur E. Raabe (A.M.), Vice-President, Bendix Aviation Corporation, has been appointed General Manager of Bendix's Eclipse-Pioneer Division. Mr. Raabe has been an executive of the corporation since its inception in 1929.

E. M. Owen (M.), Head, newly consolidated department of all flight operations, Northrop Aircraft, Inc. Formerly, Representative for Curtiss-Wright Corporation, Washington, D.C.

Howard C. Rodean (T.M.), Power Plant Analyst, Chance Vought Aircraft Division, United Aircraft Corporation. Formerly Air Materiel Command, Wright-Patterson Air Force Base, Dayton, Ohio.

Stanley Rosenfeld (T.M.), now Stress Engineer, Kaman Aircraft Corporation.

Seymour M. Schultz (T.M.), now Preliminary Design Engineer, Gyrodyne Company of America.

Max Sokol (A.F.), Assistant Chief of Experimental Flight Test, Piasecki Helicopter Corporation. Formerly, Stress Analyst, Piasecki.

Selma C. Swift (M.), Research Engineer, Hughes Aircraft Company. Formerly, Development Engineer, Aerojet Engineering Corporation.

Edward M. Vance (M.), Research Engineer—Hydraulics, Jet Propulsion Laboratory, California Institute of Technology. Formerly, Development Design Engineer, Hydro-Aire, Inc.

Corporate Member News

• **Aerojet Engineering Corporation** . . The construction of an additional 56,000 sq.ft. of floor space now being completed includes a production machine shop and a physical sciences laboratory. The laboratory is being constructed from plans laid out by Dr. Fritz Zwicky, Aerojet's Chief Research Consultant, and Dr. Theodore von Kármán, H.F.I.A.S., Aerojet's founder and its Chief Technical Advisor.

• **Aeroproducts Division, General Motors Corporation** . . . According to the terms of a recently announced contract with Boeing Airplane Company, Aeroproducts will build actuator gearbox assemblies for the B-47 bomber.

• **AiResearch Manufacturing Company, Division of the Garrett Corporation** . . . A "sister" division is to be formed and to be known as AiResearch Manufacturing Company of Arizona. A new plant is being built on property leased on a 99-year agreement, beside Sky Harbor Airport, Phoenix, Ariz.

• **American Airlines System** . . . Three additional 52-passenger DC-6B transports have been ordered from Douglas Aircraft Company, Inc. American Airlines already had an order of eleven placed with Douglas. Delivery of the first of the 14 is expected this month.

• **Bendix Aviation Corporation** . . . The property and facilities in Davenport, Iowa, of the Victor Animatograph Corporation have been purchased. The modern factory building, which has 154,000 sq.ft. of manufacturing space, will be used to handle increased production of aircraft instruments and accessories.

• **Bendix Radio Communications Division, Bendix Aviation Corporation** . . . The C.A.A. has increased its order for Airport Surveillance Radar and Precision Approach Radar systems to include five additional A.S.R. systems and one additional P.A.R. system. This brings the total number ordered by the C.A.A. of A.S.R. systems to 19 and of P.A.R. systems to 15.

• **Brown Instruments Division, Minneapolis-Honeywell Regulator Company** . . . *Technical Bulletin No. B51-2* has been published. Its title is "Fundamentals of Industrial Electrochemical Measurements and Automatic Control" (pH, Redox, and Conductivity). It is written by S. D. Ross.

• **Clifford Manufacturing Company, Division of Standard-Thomson Corporation** . . . A bulletin, "What to Consider When Selecting a Metallic Bellows," available gratis, contains information on bellows, including charts, diagrams, applications, detailed analysis of bellows' construction, materials, flexibility, filling medium, and life.

• **Consolidated Vultee Aircraft Corporation** . . . The production of a new model 40-passenger Convair-Liner commercial transport has been started. Among other improvements to be incorporated in the new transport, designated the Model 240-A, is a substantial increase in gross weight, raising the maximum to 43,575 lbs., compared with 41,790 lbs. for the current model . . . Fort Worth Division's new aircraft testing laboratories are scheduled to go into operation this year. The test lab will have what is said to be one of America's most complete industry-operated setups for environmental testing of aircraft . . . A modernized B-36 bomber made an extended test flight last December. This ship was the first of an undisclosed number of early model B-36B bombers being modernized to B-36D's. The addition of four jets and other improvements make these equal in performance and equipment to the B-36D series now in production at Forth Worth . . . The B-36D has completed a 1,000-hour accelerated service test program at the Fort Worth Division . . . The B-36F bomber has undergone flight tests at the Fort Worth Division. This new model, in addition to four jet engines, is equipped with six Pratt & Whitney piston engines, each producing 3,800 hp. This piston engine, technically known as R-4360-53, is a development of the 3,500-hp. engines used on the B-36D.

• **Cornell University** . . . A $1,700,000 laboratory for the study of materials and methods of processing them will become the second unit in the new engineering development. The center consists of two adjoining units—a Materials Laboratory and a Materials Processing Laboratory. With construction beginning as soon as conditions permit, the center is scheduled for completion sometime in 1952.

• **Douglas Aircraft Company, Inc.** . . . KLM, the Royal Dutch Airlines, have placed an order for seven of the latest-type 365-m.p.h. DC-6B transports.

• **Eaton Manufacturing Company** . . . According to reports, the recent fire and explosion at Eaton's Battle Creek plant will not affect the nation's jet-turbine blade production as much as was at first feared. With the cooperation of Allison Division of General Motors Corporation, Wright Aeronautical Corporation, and the Government, machines to replace some of those destroyed in the fire have been obtained. These have been set up in available space in one of Eaton's other buildings at Battle Creek.

• **Fairchild Aircraft Division, Fairchild Engine and Airplane Corporation** . . . A new device, called the "thermostatograph," has been developed for testing the operating points of heater switches before their installation in heater systems of the C-119 Packet. Types that can be tested include low-temperature cut-off switches and heater cycling and overheat switches. While they are being tested at calibrated heater operating temperatures, their performance is recorded on a paper tape.

• **General Electric Company** . . . A new 8-page, two-color bulletin on "X-Ray Photometer for Chemical Analysis by X-Ray Absorption" is available. Designated as *Publication GEC-412A*, it lists some of the applications for the instrument in the petroleum and chemical industries. Among other information included is an explanation of the theory of operation, principal components, and operating procedure of the X-ray photometer.

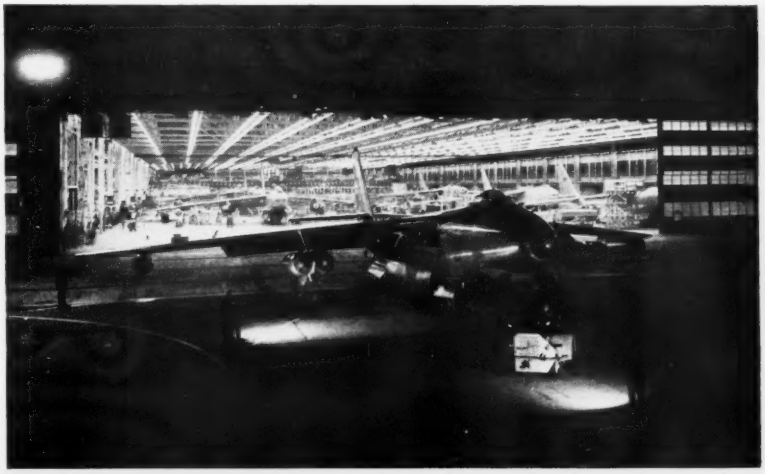
• **Goodyear Aircraft Corporation, The Goodyear Tire & Rubber Company** . . . A new foamed-in-place radome fabrication process was demonstrated to the aircraft industry recently. The new process involves the use of alkyd-isocyanate foam with fiberglas skins and was developed to meet the needs of higher electrical performance of radar equipment . . . Under the terms of a subcontract with Piasecki Helicopter Corporation, Goodyear is scheduled to manufacture parts of the H-21 Arctic Rescue Helicopter. The parts include complete fuselage shells and "omniphibious" landing gears. The contract, which runs well into 1952, also includes detail design and production engineering. The H-21 has provisions for up to 20 troop seats but in an emergency can handle 27 persons on the cabin floor.

• **Lear, Incorporated** . . . The new Unicom transceiver, a compact two-way V.H.F. voice communication system for use by fixed-base operators at airports not equipped with tower facilities, has been announced. The Unicom is designed to operate on the newly designated 122.8 mc. "private fliers' universal communications frequency" and incorporates a crystal-controlled, single-channel V.H.F. tunable receiver, speaker, microphone, a.c. power supply, antenna, and 60-ft. antenna cable. The unit (containing the transmitter, receiver, power supply, and speaker) measures 13 in. long by 8¾ in.

(*Continued on page 98*)

STRATOJET ACTIVITY

Snapped at the Wichita Division of Boeing Airplane Company, this picture reflects the expanding activities of the U.S.A.F.'s Boeing B-47 Stratojet medium-bomber program. This swept-wing, 185,000-lb., 600-m.p.h. bomber, which is being built in quantity for the Air Force's Strategic Air Command, is now powered by six General Electric J-47 turbojet engines of 5,200 lbs. of thrust each.



Editorial

Presidential Shift—

The quality of I.A.S. leadership is not strained. One of the greatest tributes to the standing of this organization in the aeronautical world is the continuing willingness of top figures in industry, in research, and in education to serve as our Officers and Councilors. The list of our past and present officers is in itself a Blue Book of American Aeronautics.

Nor do these people serve in any nominal capacities. The acceptance of high office in the Institute carries with it an obligation that has never been side-stepped. Even in these days of stress, when the men who carry the load of our present expansion programs are under constant pressure from many directions, your Officers and Council have always been willing to take the time and give of their energies to guide and support the management of the Institute.

The name of "Dutch" Kindelberger was added to the list of Past-Presidents at the 1951 Honors Night Dinner. As the head of one of our most important industry groups—one of the strong links in the chain of our national defense—he has much on his mind, and demands on his time are tremendous. But as he steps down from office, he leaves the Institute in the strongest position in its history, and we all extend to him our thanks and appreciation for the part he has played in achieving that result. As is customary, "Dutch" will remain as a member of the Council for the coming year. In this way we will continue to benefit from his advice and counsel.

Our incoming President, Rear Adm. L. B. Richardson, U.S.N. (Ret.) is of the same caliber as his distinguished predecessors. Against his wide background of service both in the armed services and in industry, his qualifications for leadership of your Institute in the coming year stand out in clear focus. A national emergency is on us, and we could look far to find one better qualified to guide I.A.S. affairs more capably than our new President. We pledge him our fullest confidence in the difficult year ahead. And the outlook is most uncertain. It may well be that before these lines are printed this country may again be engaged in a full-scale war. From day to day the future hangs in the balance. We must all make our plans—both personal and business—subject to change to meet any possible contingency.

The greatest task before us is to fit every I.A.S. activity into the pattern of the national defense. No one of us, as individuals or as a part of an organization, can afford to waste any effort in nonessentials. Our meetings, our publications, our discussions, and all our activities must have but one objective—the preservation of our country and of freedom in the world. Never before has it been of greater importance to keep constantly before us the major mission of the Institute of the Aeronautical Sciences—to put into the hands of America's airmen the best aircraft that any of us know how to dream up and produce. To labor for any lesser objective is to betray our trust. S. P. J.

J. H. ("Dutch") Kindelberger
Retiring I.A.S. President

The Upper Atmosphere—

*Its Exploration and Exploitation**

By Willy Ley

DURING THE LAST TEN YEARS there has been an enormous and increasing, one may even say "accelerated," interest in a field of research which used to be rather specialized—namely, the upper atmosphere. That growth of interest has proceeded in two directions. Partly, it has experienced an intensification among those who always had it, enhanced by new means of investigation, principally high-altitude rockets. More important for the whole, however, has been the spread of that interest to other fields, involving larger numbers of people. Once only meteorologists and, to some extent, astronomers were concerned about the upper atmosphere. Nowadays this concern is shared by military men, missile designers, rocket specialists, and experts from the whole and varied field of aerodynamics.

The reason is easy to understand. As long as aviators considered 20,000 ft. a high altitude for their practical purposes, their interest in meteorological matters was more or less restricted to those 20,000 ft. They were interested in weather, not in the atmosphere. But since the advent of turbojets and ram-jets and the various possibilities of rockets, the higher atmosphere has come to be a field that is not only to be explored for the sake of pure knowledge but which will be exploited by practical engineering in the near future.

Originally, the upper atmosphere was not even the domain of the meteorologists, because the science of meteorology did not yet exist, except in the realm of lofty and philosophical thoughts. The man who first tried to give what would now be called an atmosphere model was Aristotle. I would not mention his purely philosophical concept at all if it were not for the fact that it sounds curiously prophetic to us. He divided the atmosphere into three layers. The bottom layer, touching the ground, was in irregular motion and had varying temperatures. The middle layer was intensely cold, a reasoning probably prompted by experiences on high mountains. And the top layer, touching the fiery heavens, was intensely hot.

Afterward, interest in the high atmosphere shifted from the philosophical department to astronomy. In fact, the earliest figure ever given for the atmosphere came from Arab astronomy. To the Arabs, the earth

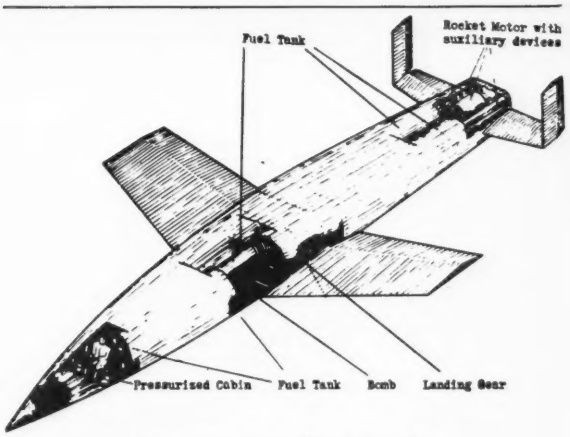
* Lecture delivered at the I.A.S. New York Section Meeting on October 10, 1950.

was indisputably a sphere floating freely in space. It was assumed that the atmosphere had a limit, and, consequently, there were attempts to establish its height by calculation from the duration of the twilight. The figure arrived at was 92 km. or 57 miles. As far as I know, historians of astronomy have not been able to ascertain who made this calculation, but it is suspected that it was the Arab atronomer, al-Biruni, who died in 1048 A.D. The next man in chronological sequence who proposed an atmosphere model was also essentially an astronomer, the famous Dr. Edmond Halley (1714). By assembling observations made by mountain climbers and filling in the gaps by calculations, he also arrived at the conclusion that the atmosphere had to consist of three main layers. The bottom layer, characterized by steadily decreasing temperature as one ascended in it, had a depth of 9 miles. The middle layer, characterized by an extremely low but steady temperature, was supposed to extend from 9 to 18 miles, and the top layer, characterized by a further steady drop in temperature, was supposed to reach to a height of 45 miles.

Most of this sounds modern, indeed, except that the figures used appear to be too small to us. We agree with Dr. Halley's figure for the troposphere but consider his figure for the total as somewhat low for the top of the stratosphere. But this is much more recent knowledge; even the two terms just used for the bottom and middle layers were invented only about 60 years ago by the French meteorologist, Léon P. Teisserenc de Bort. And the term "ionosphere" for the top layer did not originate until after World War I.

During the time interval between Dr. Halley and Teisserenc de Bort, the means of investigation had improved from mountain climbing via the manned balloon to unmanned balloons carrying recording instruments. Telemetering as applied to airborne instruments (telemetering on the ground, through a wire, was invented in 1877 by the Dutch instrument maker Olland) did not appear until about 25 years ago.

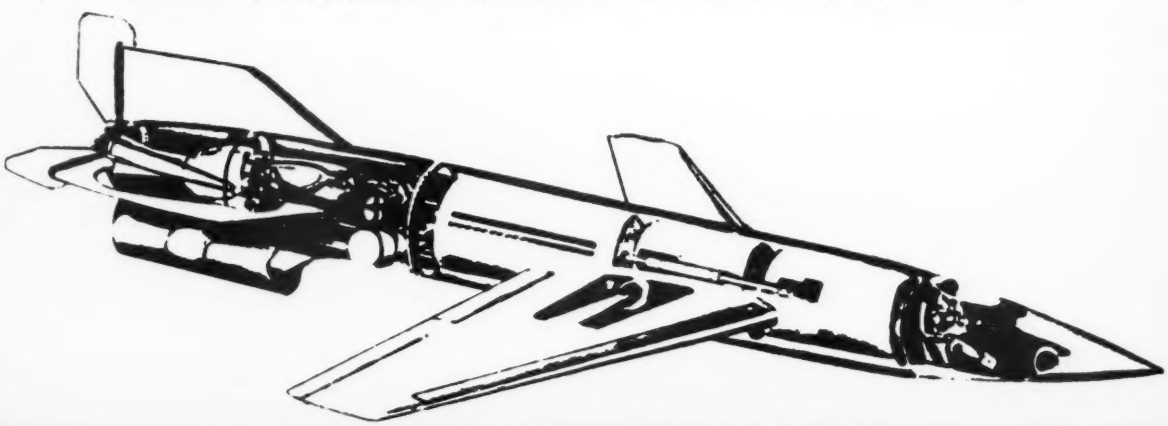
The great progress since then is only partially due to improvements in instrumentation on the one hand and refinement in telemetering techniques on the other hand. It is mostly because of the creation of devices capable of carrying instruments to high altitudes. The unmanned instrument carrying balloons of the period from, say, 1900 to 1940 did occasionally reach an altitude of 100,000 ft., but that was something that happened once in a while and could not be brought about intentionally; 35,000 ft. was "high" for these balloons, and 60,000 ft. was their ultimate ceiling except for freakish cases. Only in recent years has it been possible to build balloons that can be counted upon to attain a peak altitude of 100,000 ft. and which, on occasion, may go somewhat higher.

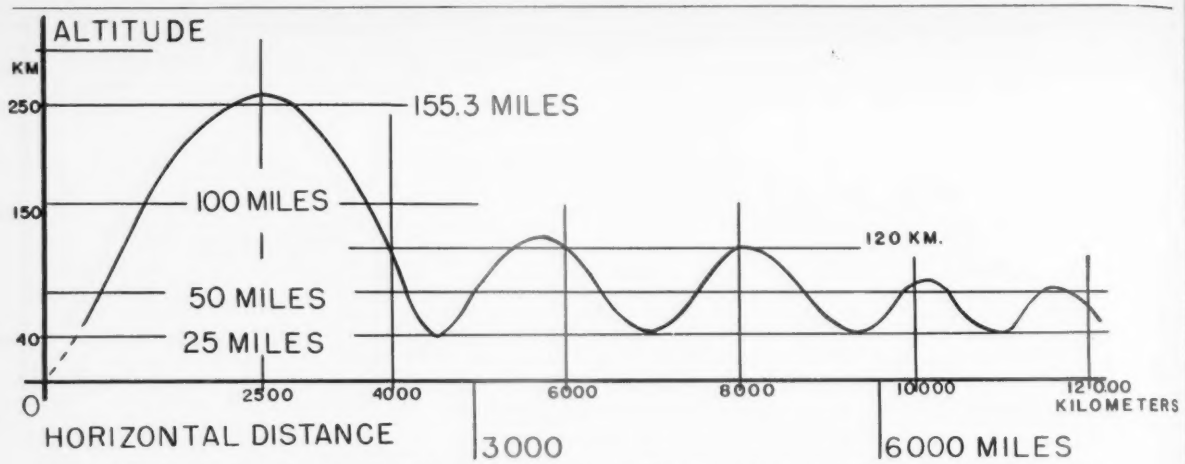


Appearance of Dr. Sänger's bomber.

To use rockets instead of balloons as instrument carriers for high-altitude research was vigorously advocated in 1920 by the late Prof. Robert H. Goddard. It is a matter of historical record that a German engineer by the name of Alfred Maul had built instrument-carrying (solid fuel) rockets in 1909 and had even obtained a patent for that idea. But Maul had only wanted to replace the balloon by a rocket for practical reasons (ease in handling, independence from wind interference, quick attainment of the desired altitude, etc.). He had not attempted to reach higher altitudes, nor would he have been successful with the black powder rockets of his day if he had tried.

German drawing of the projected A-9; overall dimensions about the same as A-4 (V-2) but different fuels.





Flight path of a rocket-propelled "plane" from one point on the equator to an approximate antipodal point, as described in the Sänger-Bredt report. Ratio between vertical and horizontal scale on this drawing equals 12.5:1. In reality the bottom line would form a semicircle.

High-altitude research by means of rocket-borne instruments began only some five years ago, but the results obtained could be used successfully to check predictions made on the basis of older methods. As an example, we may compare the figures for air pressure from the *N.A.C.A. Standard Atmosphere* (Report No. 218) with those measured above the White Sands Proving Ground in New Mexico by V-2 rocket No. 21 on March 7, 1947, as shown in Table 1.

TABLE 1

Time Since Take-Off, Sec.	Altitude, Meters	Altitude, Ft.	Pressure, Mm. of Hg, V-2 No. 21	Pressure, Mm. of Hg, N.A.C.A.
0	1,200	3,740	660	658
10	1,700	5,580	630	619
20	3,500	11,480	495	493
25	5,000	16,400	410	405
30	7,000	22,970	300	308
35	9,400	30,840	210	217
40	12,300	40,350	130	138
45	15,900	52,170	76	79
47.5	18,000	59,060	52	56
50	20,400	66,930	33	40

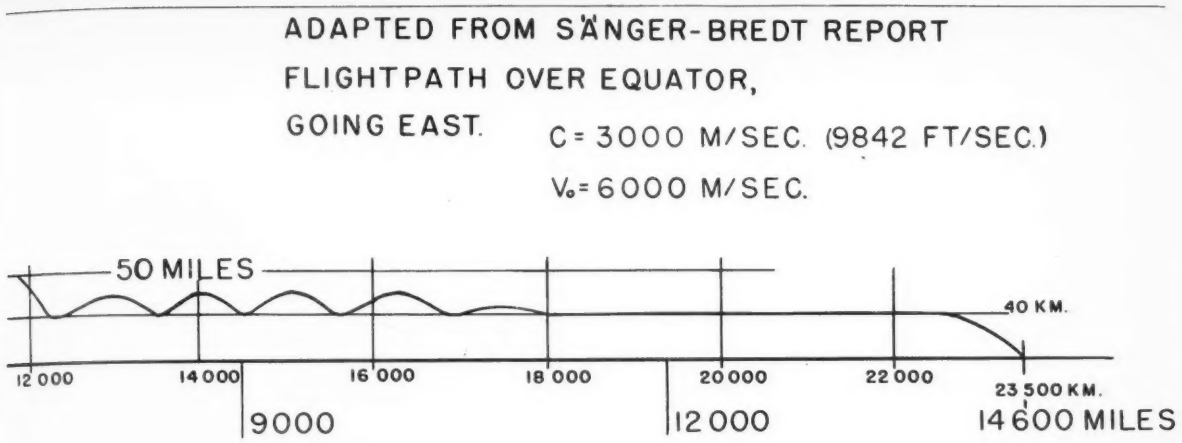
The first line refers to the elevation of the Proving Ground above sea level.

Much detail of the present concepts of the earth's atmosphere is familiar to the members of the Institute from the article by Howard E. Roberts (published in the October, 1949, issue of the AERONAUTICAL ENGINEERING REVIEW), but a few overall figures may be given here. The total weight of the atmosphere, assuming it to be completely dry, is estimated to be 5×10^{15} tons; the actual weight, including the moisture, is estimated at 5.9×10^{15} tons. Virtually all the moisture is in the troposphere, which has 79 per cent of the mass of the whole but occupies only $^1/_3$ per cent of the volume. The stratosphere, comprising 20 per cent of the total mass, occupies 2 per cent of the volume, while the ionosphere occupies almost all of the space (over 97 per cent) and has less than 1 per cent of the mass. In the higher ionosphere one can hardly talk about "atmosphere" any more since that term carries with it the connotation of a continuous medium. But at the record altitude for a single V-2 rocket, 114 miles or 183 km., the mean free path of air molecules, according to the Grimminger report, has grown to 11 meters (36 ft.) so that it is more a question of individual molecule impacts. At the record altitude reached so far, by a V-2 launched WAC-Corporal rocket on February 24, 1949, which was 400 km. (250 miles), the mean free path of the molecules is on the order of 8 km. or about 5 miles.

The astonishing lack of density in altitudes already reached is also borne out by a set of calculations which was made by Dr. Eugen Sänger, originally of Vienna, now of Paris (*Interavia*, July, 1949). Dr. Sänger tried to establish the lowest possible altitude for an orbital rocket. He assumed a rocket of a dry weight of 10 tons, moving without propulsion but with the necessary orbital velocity for the altitudes indicated. The three altitudes selected were 130 km. (81 miles), 180 km. (112 miles), and 250 km. (155 miles), all of which have been actually reached by rockets in near vertical ascents. At the altitude of 81 miles, such a 10-ton rocket would still lose some 33,000 ft. of altitude in one complete revolution around the earth. At the altitude of 112 miles, the loss of altitude per revolution would be around 3 ft.

The relationship becomes still clearer if it is expressed in the number of revolutions required to cause a loss of one per cent of the original altitude. For an altitude of 81 miles, a loss of one per cent of altitude would occur after $^1/_8$ of one complete revolution. For an altitude of 112 miles, it would need 1,800 complete revolutions to cause a loss of one per cent, and for an altitude of 155 miles, an altitude loss of 1.55 miles would not occur until after 100,000,000 complete revolutions.

For the present, we are, naturally, still more concerned with the lower layers of the atmosphere through which we fly. When we look at these layers from a practical point of view, we find a "layering" that is reminiscent and, of course, connected with the layers of



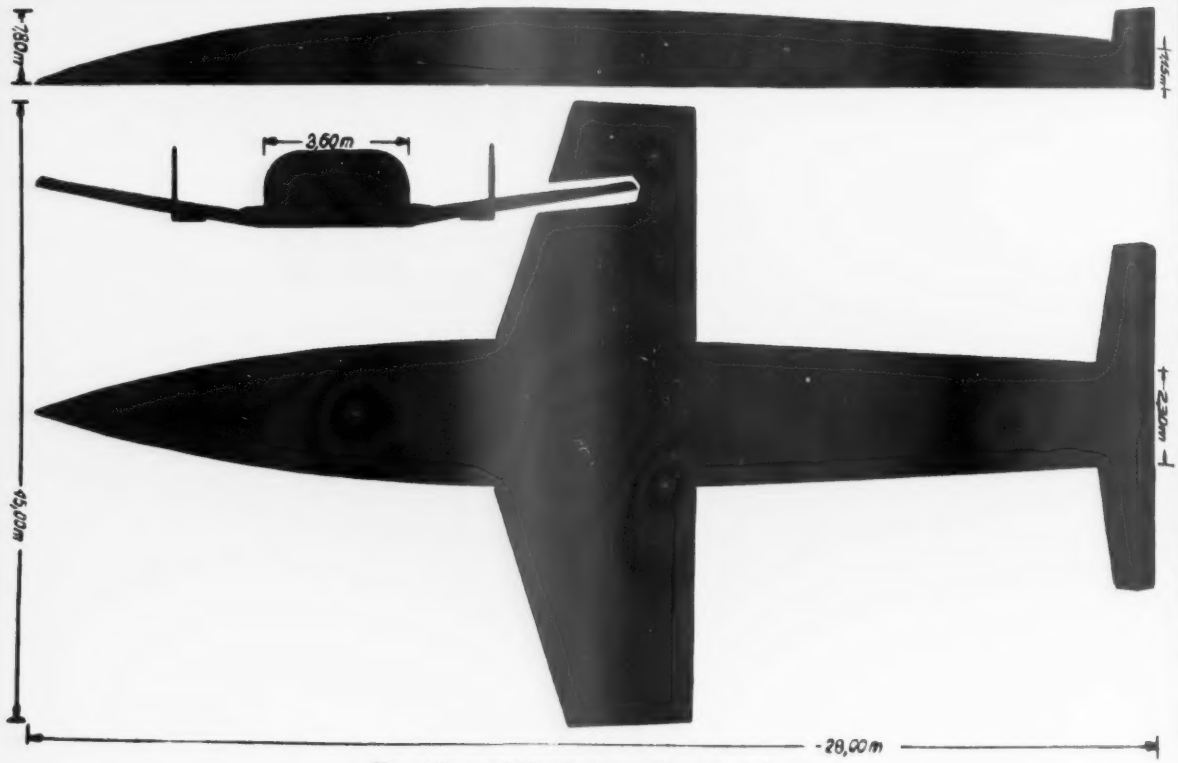
the atmosphere itself. Near the ground, from 0 to 3 km. (say 10,000 ft.), we have the realm of small aircraft without pressurized cabins, of helicopters, and of blimps. The next "layer," from 3 to 12 km. (say 10,000 to 40,000 ft.), is the realm of pressurized aircraft but still with a full range of choice of propulsion—internal combustion engines with superchargers, turbojets, or turboprops. But at the top of this "layer" the pressure has already dropped to 145 mm. of mercury, and a cubic meter of air weighs only 309 Gm., as compared to the 1,225 Gm. it weighs at sea level. The next layer, from 12 to 18 km. (40,000 to 60,000 ft.), looks like the more or less exclusive property of turbojets and ram-jets. The limit is not caused so much by lack of density as far as the supporting surfaces are concerned, but by the oxygen needs of air-breathing engines.

A fast fighter plane with internal combustion engines requires an air supply of 100 to 125 cu. ft. per sec. For jet fighters like the F-80 and F-84, the figure has risen to around 2,000 cu.ft. per sec. The figure of 60,000 ft. (pressure down to 56.6 mm. of mercury and a mean free path of the air molecules of about 0.001 mm.) is somewhat arbitrary, but it is doubtful whether aircraft with air-breathing engines will be able to fly much above that altitude.

Rocket-propelled craft can, of course, go higher, but the interesting point is that the realm of rocket "flight" will not begin where the air-breathing engines leave off. The air at, say, 12 miles, which is too attenuated to support the operations of an air-breathing engine, is still far too dense for the efficient operation of rocket vehicles. The rocket principle does not lend itself to the customary application of engine power to aircraft which may be termed "power all the time and all the way." In order to utilize the rocket principle efficiently power application has to be restricted to the take-off; afterward the rocket moves on kinetic energy.

The well-known V-2 rocket, for example, attains a velocity of almost 1 mile per sec. after 68 sec. of burning with an average fuel consumption of 125 kg. (275 lbs.) of alcohol and liquid oxygen per sec. If the velocity at the moment of fuel cutoff is directed approximately vertically, the rocket will rise to around 110 miles altitude and strike the ground some 20 to 25 miles from take-off point. If the angle at the moment of fuel cutoff is approximately 45°, a range of close to 200 miles

A typical example of an instrument-carrying rocket is this North American Aviation NATIV.



Plan of "antipodal bomber" from Sänger-Bredt Report.

and a maximum elevation of about 50 miles 100 miles from take-off point will be the result. In either case, the trajectory (except for the comparatively short section under power) is a part of an ellipse, the focal point of which coincides with the center of the earth. In actual operational use, an angle of 41° (measured from the *vertical* at take-off point) was used, resulting in a range of 189 miles with a peak altitude of 60.3 miles. On such a trajectory, the rocket entered relatively dense layers of the atmosphere at 30 km. (18.6 miles) with a velocity along the trajectory of almost 5,100 ft. per sec. From that point on to impact it was 22 miles, measured horizontally, but the velocity at impact, due to increasing air resistance, was only 2,600 ft. per sec.

After these figures had been established for V-2, the Germans conceived the idea of equipping the rocket with short sweptback wings. The projects were labeled A-4b and A-9, the difference between the two being essentially a different fuel-oxidizer combination. These wings, upon entering dense layers again, were to convert the virtually fuelless and, therefore, light rocket into a high-speed glider, and a preliminary calculation estimated an increase in range by a full 100 miles as a result. About simultaneously, Dr. Eugen Sänger studied the problem of a winged rocket entering denser atmospheric layers upon returning from much higher altitudes. Somewhat to his own surprise he found that the increase in range would be much higher because the rocket would ricochet from the denser layer, reach higher altitudes again, come down again, ricochet once more, and so forth, with gradually "dampening" undulations that would grow smaller in both directions, vertically as well as horizontally. Needless to say, this flight path was nicknamed "roller coaster trajectory."

Before I give one example, the assumptions made by Dr. Sänger have to be stated. He assumed an airplane-shaped winged rocket with a take-off weight of 100 tons, an empty weight of 10 tons, and a pay load of 0.3 tons. The vehicle was to be catapulted off a hori-

(*Continued on page 30*)

TABLE 2

	Distance from Take-Off Point, Measured Along the Surface, Km.	Altitude Above S.L., Km.
First peak	2,500	260
First low	4,500	40
Second peak	5,750	125
Second low	7,000	40
Third peak	8,200	120
Third low	9,400	40
Fourth peak	10,200	90
Fourth low	10,900	40
Fifth peak	11,600	82
Fifth low	12,300	40
Sixth peak	13,000	60
Sixth low	13,500	40
Seventh peak	14,200	60
Seventh low	14,500	40
Eighth peak	15,100	60
Eighth low	15,700	40
Ninth peak	16,300	60
Ninth low	16,800	40
Tenth peak	17,500	43
Tenth low	18,000	40

A Method of Calculating the Landing Flare Path of an Airplane

ROBERT D. FUSFELD*

North American Aviation, Inc.

SUMMARY

The landing flare path of an airplane is studied in this paper by reducing the system to one with two degrees of freedom. Formulas are presented which describe the motion produced by (1) a constant normal load factor, (2) a special case of a variable load factor, and (3) a sudden application of power.

INTRODUCTION

SEVERAL SEMIEMPIRICAL METHODS of predicting the landing flare path of an airplane have been proposed.[1-3] In this paper a somewhat different treatment of the problem will be given. Certain simplifying assumptions will be made which reduce the equations of motion of the airplane to a form that can be solved analytically. These assumptions, although consistent with reality, will not be based directly on experimental data or on any fixed pilot technique. It is believed that results obtained in this way will be particularly suitable for use in the development of automatic instrument-landing systems and for the study of unconventional airplane designs.

The first simplification of the problem is made by requiring that the path lie in a vertical plane through the airplane center of gravity. In other words, the airplane executes plane motion with three degrees of freedom. No error is introduced by this step, but it excludes the possibility of studying the effect of lateral forces produced by gusts or control-surface deflections.

A further simplification can be realized if one of the degrees of freedom is eliminated. Suppose that an arbitrary constraint is placed on the motion in pitch by specifying, in some logical manner, the normal load factor. The problem is then reduced to that of a point mass moving in a plane with two degrees of freedom under the action of known forces.

Of all the possible assumptions that could be made about the motion in pitch, three special cases will be studied in detail. (1) A constant load factor during the flare will be used to calculate the motion of an airplane having a rapid response to control surface movements. (2) A sinusoidal type of load factor variation will be used to calculate the motion of an airplane having a slow response to its controls. (3) The flare due to a sudden application of power will be studied.

NOMENCLATURE

A = constant of integration
a = coefficient in a Fourier series
B = constant of integration
b = coefficient in a Fourier series
C = constant of integration
D = drag, lbs.
g = acceleration of gravity, ft. per sec.^{2}
h = altitude, ft.
k = integer used in a Fourier series
L = lift, lbs.
m = mass, slugs
n = normal load factor $= L/W$
p = a constant, maximum value of $(n - 1)$
T = thrust, lbs.
t = time, sec.
u = velocity increment along flight path, ft. per sec.
V = velocity along flight path, ft. per sec.
v = vertical velocity, ft. per sec.
W = weight, lbs.
X = horizontal distance, ft.
α = angle of attack, rad.
θ = flight path angle, rad.

Subscripts

1 = start of flare ($t_1 = 0$ and $x_1 = 0$)
2 = end of flare
k = 1, 2, 3, etc. = integer used in a Fourier series

DERIVATION OF EQUATIONS OF MOTION

The longitudinal forces that act on an airplane in flight are shown in Fig. 1. If Newton's Law of Motion is applied to the airplane in directions normal and tangent to the flight path, two equations involving the unknowns V and θ are obtained. These are

$$m(dV/dt) = T \cos \alpha - D - W \sin \theta \qquad (1)$$

and

$$mV(d\theta/dt) = T \sin \alpha + L - W \cos \theta \qquad (2)$$

For usual landing approaches, α and θ are small enough to assume that

$$\sin \theta \doteq \theta$$
$$\cos \alpha \doteq \cos \theta \doteq 1$$

Also, for the small values of thrust which would be used in landing, the term $T \sin \alpha$ is small compared to the

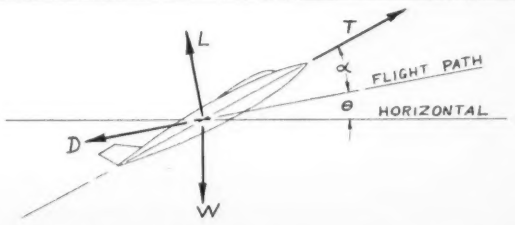


FIG. 1. Forces acting on an airplane.

* Aerodynamicist.

lift and will be neglected in accordance with usual practice. When these approximations are introduced, the equations of motion can be rearranged and written in the form

$$\frac{dV}{dt} = g\left(\frac{T}{W} - n\frac{D}{L} - \theta\right) \tag{3}$$

$$V(d\theta/dt) = g(n-1) \tag{4}$$

Eqs. (3) and (4) may be integrated numerically to determine the flight path for any initial conditions and any arbitrary values of n, T/W, and D/L. The purpose here, however, is to obtain analytic solutions. First, a solution for a constant load factor flare will be derived. Other solutions will be found after simplifying the equations of motion.

Flare with Constant Load Factor

If the time required for the airplane to respond to a control surface movement is small compared to the time required to execute the flare, a constant load factor can effectively be maintained. The change in load factor at the beginning and end of the flare will approximate a step function, and the load factor during the flare can easily be held constant.

In addition to a constant load factor, both thrust and D/L will be called constants. Thrust, of course, is under the control of the pilot and can be set at any specified value. The drag-lift ratio, however, will vary with the lift coefficient and with distance above the ground. The value of D/L in the glide has been found to be a good value to use in calculations. The increase due to the greater lift coefficient during the flare tends to compensate for the decrease due to ground effects. In any event, a small error in the value of D/L will not seriously affect the results.

With the above assumptions, the equations of motion can be solved. Dividing Eq. (3) by Eq. (4) and multiplying by the differential $d\theta$,

$$\frac{dV}{V} = \frac{[(T/W) - n(D/L) - \theta]}{(n-1)}\,d\theta \tag{5}$$

The variable t has now been eliminated and the remaining variables V and θ have been separated. Integrating,

$$\ln V = \frac{[(T/W) - n(D/L)]\theta - (1/2)\theta^2}{(n-1)} + C \tag{6}$$

The constant of integration can be evaluated by noting that, when $V = V_1$, $\theta = \theta_1$. The relation between V and θ then becomes

$$\ln \frac{V}{V_1} = \frac{\left(\frac{T}{W} - n\frac{D}{L}\right)(\theta - \theta_1) - \frac{1}{2}(\theta^2 - \theta_1^2)}{(n-1)} \tag{7}$$

If this expression for V is substituted into Eq. (4) and if some algebraic manipulations are made, the following differential equation relating θ and t is obtained:

$$e^{\left\{\left[\left(\frac{T}{W} - n\frac{D}{L}\right)(\theta - \theta_1) - \frac{1}{2}(\theta^2 - \theta_1^2)\right]/(n-1)\right\}}d\theta = \frac{g(n-1)}{V_1}\,dt \tag{8}$$

Even though the variables have been separated, Eq. (8) cannot be integrated in terms of elementary functions. Therefore, although the problem has been solved in principle, the flight path cannot be written in an analytic form. The results obtained, however, will be useful in evaluating the accuracy of solutions to be obtained by a less rigorous method. For this purpose, the total velocity change will be calculated for a flare ending with the flight path tangent to the ground. Thus,

$$\frac{u_2}{V_1} = e^{-\left\{\left[\left(\frac{T}{W} - n\frac{D}{L}\right)\theta_1 - \frac{1}{2}\theta_1^2\right]/(n-1)\right\}} - 1 \tag{9}$$

For the case where $T/W = 0$, $D/L = -\theta_1$ and

$$u_2/V_1 = e^{-\theta_1^2[n - (1/2)]/(n-1)} - 1 \tag{10}$$

Simplification of Equations of Motion

The velocity along the flight path can be written in the form

$$V = V_1 + u \tag{11}$$

Then, $dV/dt = du/dt$ and $\theta = v/(V_1 + u)$.

Expanding θ in a power series,

$$\theta = \frac{v}{V_1}\left(1 - \frac{u}{V_1} + \frac{u^2}{V_1^2} - \frac{u^3}{V_1^3} + \cdots\right) \tag{12}$$

The value of u/V_1 may reach a maximum of about 1/10. Therefore, square terms and higher may be neglected compared to 1. Further, vu/V_1^2 is zero at both the start and the end of the flare and will give an extremely small contribution to the deceleration. Therefore, neglecting these small quantities,

$$\theta \doteq v/V_1 \tag{13}$$

The first equation of motion can now be written in the form

$$\frac{du}{dt} = g\left(\frac{T}{W} - n\frac{D}{L} - \frac{v}{V_1}\right) \tag{14}$$

Differentiating the sinking speed, $v = V\theta$, with respect to time

$$dv/dt = V(d\theta/dt) + \theta(dV/dt) \tag{15}$$

The term $\theta(dV/dt)$ is small compared to dv/dt and can be neglected when solving for $V(d\theta/dt)$. The second equation of motion then becomes

$$dv/dt = g(n-1) \tag{16}$$

This is equivalent to writing the equation of motion in a vertical direction and neglecting $n(D/L)\theta$ and $(T/W)(\theta + \alpha)$ compared to 1.

Approximate Solution of Constant Load Factor Flare

If the assumptions of constant n, D/L, and T/W are again made, the second equation of motion, Eq. (16), can be integrated from $t = 0$ to t to give

$$v = g(n - 1)t + v_1 \tag{17}$$

Substituting Eq. (17) into Eq. (14),

$$\frac{du}{dt} = g\left[\frac{T}{W} - n\frac{D}{L} - \frac{v_1}{V_1} - \frac{g(n-1)}{V_1}t\right] \tag{18}$$

Integrating from $t = 0$ to t,

$$u = g\left(\frac{T}{W} - n\frac{D}{L} - \frac{v_1}{V_1}\right)t - \frac{g^2(n-1)}{2V_1}t^2 \tag{19}$$

If the flare ends tangent to the ground, the total time to flare is

$$t_2 = -v_1/g(n - 1) \tag{20}$$

The vertical distance through which the airplane has moved is

$$h_1 = -\int_1^2 v\,dt \tag{21}$$

$$h_1 = v_1^2/2g(n - 1) \tag{22}$$

The horizontal distance between the start of flare and the ground contact point is

$$X_2 = \int_1^2 V\,dt \tag{23}$$

$$X_2 = V_1\int^2 dt + \int_1^2 u\,dt \tag{24}$$

$$X_2 = -\frac{v_1V_1}{g(n-1)} \times \left[1 - \frac{v_1\left(\frac{T}{W} - n\frac{D}{L} - \frac{v_1}{V_1}\right)}{2V_1(n-1)} - \frac{v_1^2}{6V_1^2(n-1)}\right] \tag{25}$$

The last two terms in the bracket are small compared to 1; therefore,

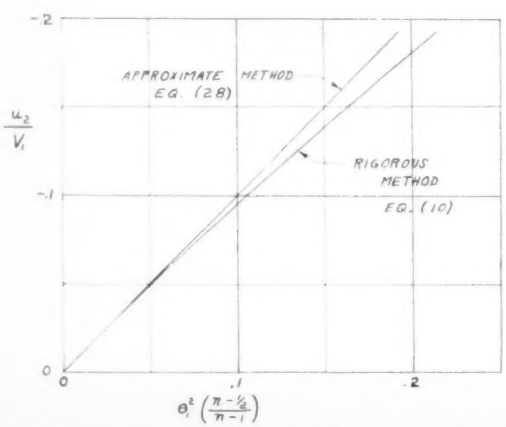


Fig. 2. Comparison of methods of calculating velocity change during constant load factor flare.

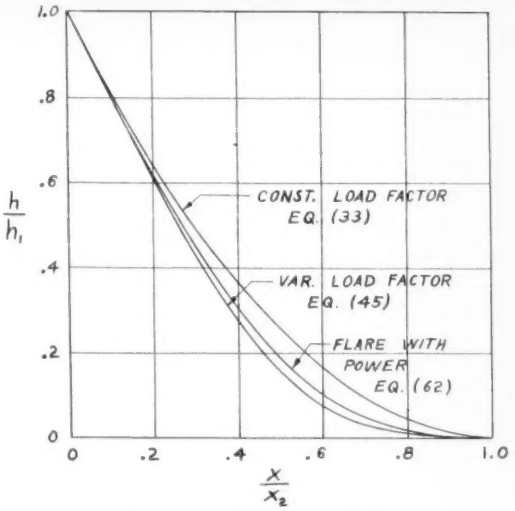


Fig. 3. Nondimensional flare paths.

$$X_2 \doteq -[v_1V_1/g(n - 1)] \tag{26}$$

The total change in velocity is

$$\frac{u_2}{V_1} = -\frac{v_1\left(\frac{T}{W} - n\frac{D}{L} - \frac{1}{2}\frac{v_1}{V_1}\right)}{V_1(n-1)} \tag{27}$$

When $T/W = 0$, this becomes

$$u_2/V_1 = -\theta_1^2\{[n - (1/2)]/(n - 1)\} \tag{28}$$

Numerical results from Eq. (28) are compared with the results of the more rigorous method, Eq. (10), in Fig. 2. For values of u/V_1 up to about 1/10, which are the maximum to be expected in normal flares, it can be seen that the approximate results are within the usual requirements on accuracy in engineering calculations.

The final part of the constant load factor flare study will be a determination of the flight path. In the vertical direction,

$$h = h_1 + \int_0^t v\,dt \tag{29}$$

Solving for h/h_1,

$$h/h_1 = 1 - 2(t/t_2) + (t/t_2)^2 \tag{30}$$

In the horizontal direction,

$$X = \int^t V\,dt = V_1\int_0^t dt + \int_0^t u\,dt \tag{31}$$

It was seen before, however, that $\int u\,dt$ is negligible compared to $V_1\int dt$. The result is simply

$$X/X_2 = t/t_2 \tag{32}$$

Combining Eq. (30) and Eq. (32),

$$h/h_1 = 1 - 2(X/X_2) + (X/X_2)^2 \tag{33}$$

This nondimensional flare path is plotted in Fig. 3.

Flare with a Variable Load Factor

When the response of the airplane to a sudden control movement is slow compared to the time required to execute the flare, the load factor cannot be considered constant. There must be a variation from $n = 1$ at the start of the flare to some maximum value and then a decrease to $n = 1$ again at the end of the flare. If the flare does not end with $n = 1$, the airplane will rise after touching the ground.

Any load factor curve can be expanded in a Fourier series over the time interval $t = 0$ to $t = t_2$ as follows:

$$n = a_0 + \sum_{k=1}^{\infty} a_k \cos k\pi \frac{t}{t_2} + \sum_{k=1}^{\infty} b_k \sin k\pi \frac{t}{t_2} \qquad (34)$$

Such a series could be substituted directly into the simplified form of the equations of motion and a general solution obtained. For this study, however, there will be selected the special case where

$$a_0 = 1 + (p/2)$$
$$a_2 = -p/2$$
$$a_k = 0, \quad b_k = 0, \qquad (\text{for } k \neq 2)$$

This gives

$$n - 1 = (p/2)\,[1 - \cos 2\pi(t/t_2)] \qquad (35)$$

where p is the maximum value of $(n - 1)$.

The load factor variation given by Eq. (35) was selected not only for its simplicity but for the following reason: Suppose that t_2 is arbitrarily specified as being equal to the period of the short oscillation in pitch. Then, over the first half of the flare, Eq. (35) will give a fairly close approximation to the response of the airplane to an abrupt elevator deflection. This is illustrated in Fig. 4, where Eq. (35) is compared with the load factor calculated for a hypothetical airplane. The airplane was assumed to have a short oscillation in pitch that damped to half amplitude in one-quarter of a cycle. In the calculation it was also assumed that the velocity along the flight path was constant. In addition to the fair agreement between the assumed and the calculated load factors during the first half of the flare, it can be seen that a simple elevator program also gives good agreement during the last half.

When t_2 is equal to the period of the short oscillation in pitch, the fastest possible flare is made. Any greater

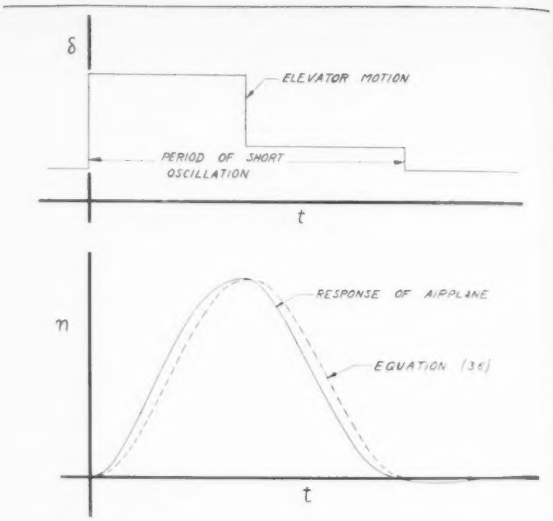


Fig. 4. Comparison of assumed load factor variation given by Eq. (36) with the response of a typical airplane to an elevator deflection program.

time, of course, can be used. In such a case the airplane elevator deflection program would have to be modified to obtain close agreement between the assumed and the actual load factor. As t_2 is made greater, the elevator deflection becomes less abrupt.

Returning to Eq. (35), it is put into the form

$$n - 1 = p \sin^2 \pi(t/t_2) \qquad (36)$$

Inserting this in the second equation of motion, Eq. (16),

$$dv/dt = gp \sin^2 \pi(t/t_2) \qquad (37)$$

Integrating between the limits $t = 0$ and t,

$$v - v_1 = gp\left(\frac{t}{2} - \frac{t_2}{4\pi} \sin 2\pi \frac{t}{t_2}\right) \qquad (38)$$

It is possible to evaluate p now by noting that $v = 0$ when $t = t_2$. Thus,

$$p = -2v_1/gt_2 \qquad (39)$$

Using the assumptions of constant D L and T/W, as in the case of the constant load factor flare and proceeding in an analogous manner, the following results are obtained:

$$v = v_1[1 - (t/t_2) + (1/\pi) \sin \pi(t/t_2) \cos \pi(t/t_2)] \qquad (40)$$

$$u = g\left[\frac{T}{W} - \frac{D}{L} - \frac{v_1}{V_1} + \frac{(D/L)v_1}{gt_2}\right]t + \frac{gv_1}{2V_1t_2}t^2 - \frac{(D/L)v_1}{2\pi} \sin 2\pi \frac{t}{t_2} - \frac{gv_1t_2}{2\pi^2V_1} \sin^2 \pi \frac{t}{t_2} \qquad (41)$$

$$u_2 = g\left(\frac{T}{W} - \frac{D}{L} - \frac{v_1}{2V_1}\right)t_2 + \frac{D}{L}v_1 \qquad (42)$$

$$X_2 = V_1t_2 \qquad (43)$$

$$h_1 = -(1/2)v_1t_2 \qquad (44)$$

$$\frac{h}{h_1} = 1 - 2\frac{X}{X_2} + \left(\frac{X}{X_2}\right)^2 - \frac{1}{\pi^2} \sin^2 \pi \frac{X}{X_2} \qquad (45)$$

The nondimensional path is illustrated in Fig. 3 (see page 27).

Flare with Power

The airplane can be flared by a sudden application of power while at a constant lift coefficient.

If the plane was originally gliding at $n = 1$, the load factor in the flare will be

$$n = (V/V_1)^2 \tag{46}$$

Expanding in terms of Eq. (11) and neglecting the square of u/V_1,

$$n = 1 + 2(u/V_1) \tag{47}$$

The simplified equations of motion, Eqs. (14) and (16), become

$$\frac{du}{dt} = g\left(\frac{T}{W} + \Delta\frac{T}{W} - \frac{D}{L} - 2\frac{D}{L}\frac{u}{V_1} - \frac{v}{V_1}\right) \tag{48}$$

$$dv/dt = 2g(u/V_1) \tag{49}$$

where $\Delta(T/W)$ is the increment of T/W used to flare. Differentiating Eq. (48) with respect to time and inserting Eq. (49),

$$\frac{d^2u}{dt^2} + 2\frac{g}{V_1}\frac{D}{L}\frac{du}{dt} + \frac{2g^2}{V_1^2}u = 0 \tag{50}$$

Neglecting $(D/L)^2$ compared to 2, the general solution of Eq. (50) is

$$u = e^{-(g/V_1)(D/L)t}\left(A \sin \sqrt{2}\,\frac{g}{V_1}t + B \cos \sqrt{2}\,\frac{g}{V_1}t\right) \tag{51}$$

To evaluate B, it is noted that $t = 0$ when $u = 0$. Therefore, B must be zero. Differentiating the remaining expression and setting $du/dt = g\Delta(T/W)$ when $t = 0$,

$$A = V_1\Delta(T/W)/\sqrt{2} \tag{52}$$

The final expression for u is

$$u = \frac{V_1\Delta(T/W)}{\sqrt{2}}\, e^{-(g/V_1)(D/L)t} \sin \sqrt{2}\,\frac{g}{V_1}t \tag{53}$$

Substituting Eq. (53) into Eq. (49),

$$\frac{dv}{dt} = \sqrt{2}g\Delta\frac{T}{W}\, e^{-(g/V_1)(D/L)t} \sin \sqrt{2}\,\frac{g}{V_1}t \tag{54}$$

Integrating from $t = 0$ to t and remembering that $(D/L)^2 \ll 2$,

$$v - v_1 = V_1\Delta\frac{T}{W}\left[1 - e^{-(g/V_1)(D/L)t}\left(\cos \sqrt{2}\,\frac{g}{V_1}t + \frac{1}{\sqrt{2}}\frac{D}{L}\sin \sqrt{2}\,\frac{g}{V_1}t\right)\right] \tag{55}$$

The results for u and v given by Eqs. (53) and (55) correspond to the long oscillation in pitch or the phugoid motion.

Thus far, a solution has been obtained for the motion of an airplane caused by any abrupt change in thrust. This could be a transition from one steady-state flight condition to another, as well as a landing flare. It is now required to find the minimum value of thrust such that the airplane will be brought tangent to the ground. Any value greater than this will cause the airplane to rise after completing the flare, and any value less than this will never reduce the sinking speed to zero.

A minimum value of sinking speed is reached when

$$dv/dt = 2g(u/V_1) = 0$$

This occurs for the first time after $t = 0$, when

$$t = \pi V_1/\sqrt{2}g \tag{56}$$

For $v = 0$ at this time,

$$\Delta(T/W) = -(v_1/V_1)\,[1/(1 + e^{-(\pi/\sqrt{2})(D/L)})] \tag{57}$$

The horizontal and vertical velocity perturbations for this particular value of $\Delta(T/W)$ become

$$u = -\frac{v_1}{\sqrt{2}(1 + e^{-(\pi/\sqrt{2})(D/L)})}\, e^{-(g/V_1)(D/L)t} \sin \sqrt{2}\,\frac{g}{V_1}t \tag{58}$$

$$v = v_1\left\{1 - \frac{1}{(1 + e^{-(\pi/\sqrt{2})(D/L)})}\left[1 - e^{-(g/V_1)(D/L)t}\left(\cos \sqrt{2}\,\frac{g}{V_1}t + \frac{1}{\sqrt{2}}\frac{D}{L}\sin \sqrt{2}\,\frac{g}{V_1}t\right)\right]\right\} \tag{59}$$

The nondimensional flight path in this case contains the parameter D/L and is not in an easily used form. If it is assumed that the damping is negligible—i.e., $e^{-(g/V_1)(D/L)t} \doteq 1$—a simplified nondimensional flare path can be obtained in the following form:

$$\frac{h}{h_1} = 1 - \frac{X}{X_2} - \frac{1}{\pi}\sin \pi\frac{X}{X_2} \tag{60}$$

where

$$h_1 = -(\pi V_1^2/2\sqrt{2}\,g)\,(v_1/V_1) \tag{61}$$

$$X_2 = \pi V_1^2/\sqrt{2g} \quad (62)$$

$$u_2 = 0 \quad (63)$$

Concluding Remarks

There will be some cases where the formulas derived in this paper will not give an adequate solution to the problem. Flares starting from extremely steep glide angles, for example, are not accurately described by the simplified form of the equations of motion. Fig. 2 can be used to estimate the error due to large glide angles. At other times, it may be necessary to use different pitching motion programs. When the formulas are not applicable, a numerical integration of Eqs. (1) and (2) or Eqs. (3) and (4) can be used. Ground effects and the exact response to elevator deflections can be included in such a calculation.

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[2] Kelly, P. L., and Schumacher, L. E., *Aerodynamic Considerations in the Exponential Flare-Out for Instrument Landing Systems*, A.A.F., Air Materiel Command, Memorandum Report MCRFT-2159.

[3] Welling, O., *An Approximate Method to Predict the Transition or "Flare" Path in the Take-Off or Landing of an Airplane*, Journal of the Aeronautical Sciences, Vol. 9, No. 1, p. 17, November, 1941.

The Upper Atmosphere

(Continued from page 24)

zontal runway with a velocity of 500 meters per sec. (1,650 ft. per sec.) and then use up all its fuel in a climb of about 30°, reaching a maximum velocity at the moment of fuel-cutoff of 6,000 meters per sec., which figure, incidentally, was twice that of the assumed exhaust velocity. The flight path then would have looked as indicated in Table 2, followed by motion without noticeable changes in altitude to a distance of 22,600 km., followed by glide with loss of altitude ending at a distance of 23,500 km. at sea level.

This is admittedly a rather extreme example, dealing as it does with a flight to the antipodal point. But the major portion of the flight path of a winged rocket is above 40 km. or 25 miles.

A similar calculation, made later by Dr. Hsue-shen Tsien of Caltech, also works with a (nonundulating) flight path at an average altitude of 27 miles. The region between about 11 miles and about 25 miles therefore seems destined to stay curiously free of traffic forever because its characteristics, no longer good enough for air-breathing engines, are not good for rockets either.

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Power-Plant Installation

of the AG-14 Pusher

BEN ANDERSON* and MARVIN GREENWOOD†

Anderson, Greenwood & Company

Introduction

The Anderson, Greenwood AG-14 is a small, two-place, all-metal personal airplane with steerable tricycle landing gear and a Continental C-90 engine mounted as a pusher. It has a range of 400 miles, has a cruising speed of 110 m.p.h., and carries up to 250 lbs. of baggage, depending upon the weight of the occupants and the amount of fuel carried. (With two persons and full fuel, 80 lbs. of baggage is allowed.) Rate of climb is 700 ft. per min., and ceiling is 19,000 ft. (For complete description see Aeronautical Engineering Review, February, 1949.)

Besides providing comfortable and enjoyable transportation, it was intended from the beginning that the AG-14 should be commercially useful for observation purposes such as inspecting pipelines, livestock, irrigation systems, farm crops, etc. An exceptionally wide field of view was desired. The pusher configuration was selected because it offered the best chance of obtaining all the design objectives without decreasing performance or increasing cost appreciably.

In its finished form, the AG-14 shows unique advantages: ease of entering the cabin, low noise level, and extremely wide field of view (because of this the AG-14 may find military use as an observation and reconnaissance airplane).

As a result of using a straight, twisted, thick section wing (NACA 4418), the stalling characteristics are gentle. The airplane is extremely spin-resistant and can be made to enter a spin only with full power and from a high angle stall; under these conditions it can be forced to spin a maximum of one turn.

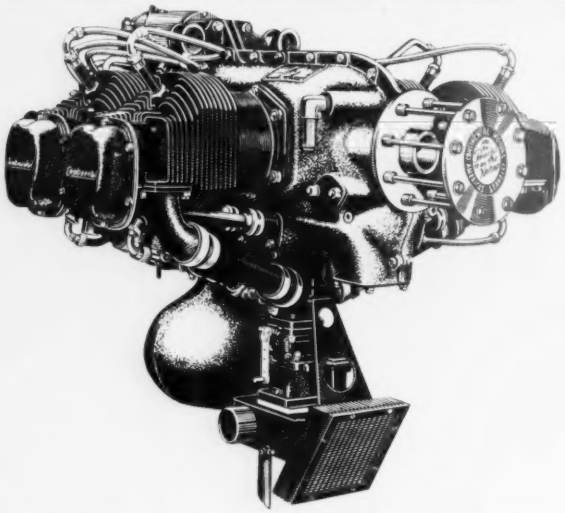
The most obvious unconventional feature of the AG-14 is, of course, the pusher power plant, the AG-14 and the B-36 being the only two pusher-powered landplanes in production in the U.S. today. Primarily, the power plant is unique in that the engine has been rotated 180° to the direction of flight and is located at the aft end of the body, complicating cooling airflow. In most other instances the engine follows accepted power-plant practice. The major differences, those connected with "reverse thrust" and engine location are: the effect of reverse thrust on the engine, carburetion and induction system, cooling airflow, special pusher propeller, short propeller extension hub, long engine control and instrument runs, and the relation of the engine to the fuel supply.

Engine and Modifications

Power is supplied by a Continental C-90-12FP four-cylinder, horizontally opposed, air-cooled engine rated

* President,.

† Vice-President, Engineering.



Continental C-90-12FP, 90-hp. air-cooled engine as furnished by engine manufacturer. For pusher installation Anderson, Greenwood rotates the carburetor 180° to compensate for reverse thrust. Air filter box is rotated 90° to facilitate ducting from side entrance scoop.

90 hp. at 2,475 r.p.m. at sea level using 80-octane minimum fuel. The engine is a standard Continental model, with a slightly modified thrust bearing to take the reverse propeller thrust, and carries the additional letter "P" to designate pusher. Oil system is of the wet sump type and is self-contained. Dual ignition, updraft carburetor, starter, and generator are supplied with the engine. Thousands of this representative type have been manufactured and have given excellent service.

Only slight changes were necessary to modify the engine for the reverse thrust. A slightly thicker thrust flange was used on the crankshaft, a $^3/_{16}$-in. oil hole in the front bearing support of the crankcase was omitted (as was an oil bleeder relief in the front main bearing support), and a baffle in the nose seal was removed to accommodate the thicker crankshaft thrust flange.

Anderson, Greenwood has found it necessary to make two installation modifications to the engine before using it as a pusher; the carburetor is rotated 180° in a horizontal plane, and the carburetor intake box is rotated 90° from its usual relation to the carburetor.

The carburetor on the C-90-12FP engine as installed by Continental has the same relation to the engine as it does in the tractor version; thus, during ground acceleration in a pusher, the fuel in the carburetor would be forced to the propeller end of the engine (opposite end to that in a tractor installation), changing the fuel metering rate for which the carburetor was designed. This results in poor acceleration during the take-off run. The fluid level relation in the carburetor is, in a climb, opposite that of a tractor in a climb; in early flights this resulted in some decrease of power and a somewhat reduced rate of climb. Rotating the carburetor 180° orients the carburetor with relation to the engine thrust and to the various flight attitudes the same as for the conventional installations.[1] Carburetion is now completely satisfactory.

The carburetor intake box was not changed in the original experimental installation. Induction air was obtained at the trailing edge of the engine cowl and was taken directly to the carburetor intake box. This resulted in a maximum negative deck pressure of only 2 in. of water (equivalent to 140 ft. of altitude) and was not expected to affect materially engine power. Because of carburetion troubles, however, it was decided to investigate the effect of this slight negative pressure, and a similar setup was made on an engine test stand. The negative pressure was duplicated by restricting the airflow to the carburetor air box. It was found that the negative pressure considerably enriched carburetor mixture with a consequent loss of engine power. Induction air is now obtained from a scoop on the right-hand side of the airplane, maintaining positive pressure at the carburetor deck at all times. Rotating the air box 90° facilitates ducting the air from the scoop to the air box.

Engine Installation

In general, the engine installation follows accepted practice for airplanes of this size. The engine is supported in a normal manner on a welded steel tube mount that not only serves the engine but also braces the aft end of the main landing gear trunnion; it is therefore a much heavier and stronger mount than if it supported the engine alone.

Separate exhaust manifolds are used for each side of the engine, two cylinders exhausting into a common pipe that conducts the exhaust forward and downward to the outlet, discharging downward so not to interfere with the propeller. Although the practice of using a common manifold for two cylinders with overlapping exhaust cycles has been questioned,[2] test stand data indicated no difference between engine operation with the manifolds described and short individual stacks.

Standard light-plane engine controls are used, except that the leads are unusually long. Bowden-type push-pull controls for mixture, throttle, and carburetor heat have a length of about 13 ft. but operate smoothly and satisfactorily. Standard light-plane engine instruments (oil pressure, oil temperature, and tachometer) are installed, again with long leads. Operation is entirely normal except that, in the instance of the oil pressure, the line is only $^1/_8$ in. in diameter and that a long time is required for the gage to begin registering after the engine is started. Some pressure will show in 15–20 sec., and normal pressure will show within a minute, but this lack of promptness can be disconcerting if the reason is not known.

The present starter control consists of a flexible control cable run from the starter down the fire-wall and forward under the floor to a foot-operated lever between the rudder pedals. This arrangement has the advantage of freeing the hands for other functions during the starting operation.

Hot air for carburetor heat is provided from a muff wrapped around the left-hand exhaust manifold. Fresh air from above the horizontal baffle plane, having already been warmed by passing over the cylinder cooling fins, is fed into the muff. Required carburetor heat rise of 90° over outside free air temperature of 30° was obtained on the first trial, and no modification of the system was necessary.

An unforeseen situation, not yet solved, occurs in the fresh-air supply to the carburetor in that incoming air, although ram air from the slipstream, enters the carburetor 12°–15° above outside free air temperature. This represents a power loss of 1–1½ per cent. No satisfactory explanation of this has been found, and a program is planned to lag the carburetor air box with insulating material and repeat flight tests to find out whether the heat rise is due to a high temperature prevailing in the lower engine compartment.

Propeller

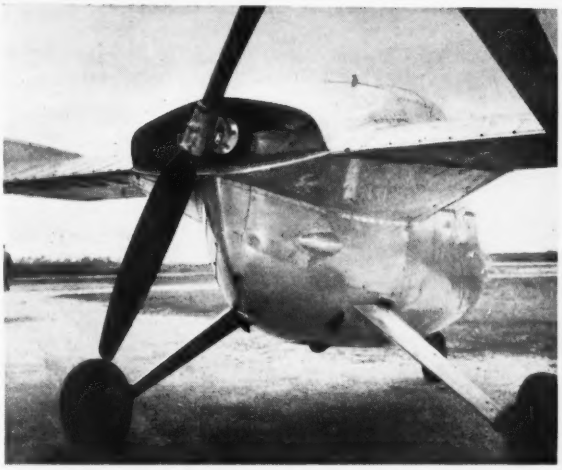
By far the best propeller so far used is the Hartzell ground-adjustable type using a metal hub and left-handed carved plastic blades; diameter is 72 in. The particular propeller used is furnished with so-called "armored tipping" over the outer 8 in. of each tip, this being a strip of solid stainless-steel bar soldered to the regular tipping and affording additional protection against damage from gravel, etc., during ground operation.

The new fixed-pitch metal propellers are not furnished in left hand, or pusher type, and have therefore not been tested.

The propeller is not attached directly to the engine shaft flange, but to a dural spacer, more or less spool-shaped and 3¾ in. long. Use of the spool permits the propeller to clear the wing trailing edge by a reasonable amount and allows shifting of the engine forward in order to secure proper balancing of the airplane. This spacer, or hub, was tested together with the pusher propeller on the modified engine by the engine manufacturer when the C-90 was certificated as a pusher.

It was discovered early in flight test that propeller clearance to the wing trailing edge was important, since cracking failures of the wing skin showed up early. On the production airplane the trailing edge was moved slightly forward, and a rounded edge was substituted for the sharp edge. No further trouble has been found, and the clearance for the propeller now stands at 6 in. Tip clearance to the boom is 8½ in.; to the ground, 15 in. Minimum C.A.A. ground clearance is 9 in.

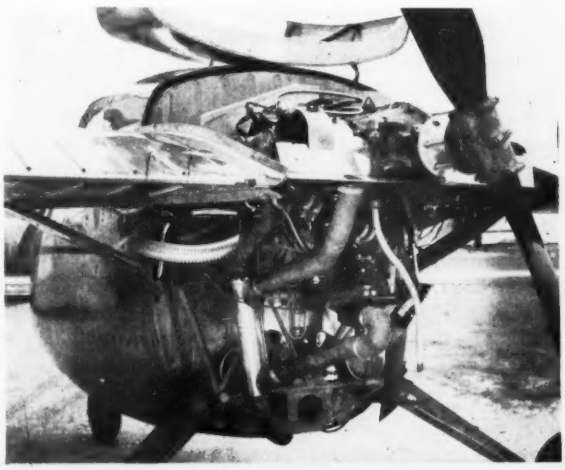
Some engine roughness was encountered during early flight tests, and, although it was believed to be propeller unbalance, balancing the propeller had little effect on it. The roughness was then attributed to wing wake-propeller interference, but it was later noted that the position of the propeller with relation to the engine crankshaft materially affected the vibration. At this time the exhaust from the engine was



directed from the cylinders aft through the propeller disc, so it seemed reasonable to expect that the exhaust could be affecting the propeller operation. The position of the exhaust outlets was moved to the present location, but even after this change the engine continued to run roughly. In desperation it was decided to balance the propeller and spacer together even though the spacer was a precision part. This seems to have solved the problem; most of the roughness was eliminated and engine operation is now considered satisfactory based on standards set for conventional tractor installations.

Cowling and Baffles

Early in the design of the AG-14, it was decided that, if at all possible, a cooling fan would not be used. Test stand results had shown that ground cooling might not be a problem (because of the low horsepower required for ground operation), so if a good source of ram air could be obtained in flight, it seemed entirely practical to eliminate a cooling fan and all the complication associated with it. As a hedge, cowling of the experimental airplane was designed so that a fan could be installed just forward of the propeller, but fortunately it was never necessary.



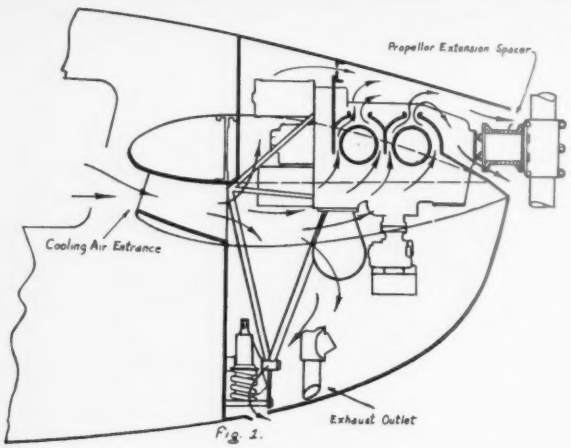


Fig. 1.

Several possible locations for obtaining cooling air were investigated, but nearly all had disadvantages. The nose of the airplane is an ideal location from the standpoint of obtaining good ram air under various flight attitudes, but this would require a large duct from the nose through the passenger compartment to the engine—an obvious disadvantage. An external duct hung below the engine compartment, similar to that on the F-51, also seemed to be a good source of ram air, but it was so close to the ground that it would pick up grass and weeds from unimproved fields and probably some dirt from the nose gear. Many other schemes that simplified construction had questionable airflow characteristics.

The present location, at the junction of the lower wing and body, seemed to offer the best compromise. Test data indicated that ram air was available under all conditions of flight and that the location below the wing did not interfere with the wing structure. Cooling air ducts in this region also facilitated engine installation by providing additional space for the exhaust system, and they served also to direct the air to the engine for efficient cooling.

Ground cooling required the cooling air exit to be located as close to the propeller disc as possible, while updraft cooling also benefited ground cooling by taking advantage of convective currents.

To the baffling and cowling problems of the engine were added the requirements of making the engine accessible for checking the oil, minor adjustments, and overhaul.

Engine cowling is removable in four pieces, uncovering the engine compartment as far forward as the firewall. The upper hatch, hinged at its forward end and lifting much as an automobile hood, exposes quickly the upper part of the engine, allowing access to work on the engine accessories and to check the oil level. The lower side cowls are fastened by Dzus buttons and, when removed, expose the carburetor and the whole lower portion of the engine.

The bottom cowl and rear post are semiquickly removable, being fastened by bolts and screws. With this cowl and the others off the airplane, the engine, with its baffles, is easily removed for overhaul. The engine compartment in the region of the wing is wide enough so that, if desired, the cylinders can be removed without removing the entire engine from the airplane.

With the exception of the duct bottoms, all cowling is compound curved and extremely rigid. The upper and side cowls are stretch-pressed, and the bottom cowl is drop-hammered.

Typical light-plane updraft baffling practice is followed in that sheet-metal baffles are employed to isolate the upper part of the engine (approximately above the horizontal centerline of the cylinders) from the lower part and to include the accessories, for cooling purposes, into the lower portion of the engine by means of a properly placed vertical baffle plane. (See Fig. 1.)

Closing the upper cowl effectively completes the ducting from the engine to the cooling air exit at the propeller, thus satisfying the requirements for ground cooling.

The entire baffle system is simple. All supports for the baffles are on the engine, and the engine and baffles can be assembled away from the airplane and installed as a whole.

In summary, cooling air for the engine enters the cooling air ducts near the leading edge of the wing and is conducted aft to the engine compartment where it flows around the engine accessories, up through the baffles, and is expelled through the propeller disc.

Cooling Experiments

The experimental AG-14 was initially powered with a Continental 85-hp. engine, but this was changed to a 90-hp. engine as soon as it was available. The Continental C-90 had not only additional power but lower allowable cooling limits for cylinder heads, barrels, and oil, thus further complicating cooling.

Originally, a "pressure-type" cooling system was employed. Air entered the two cooling ducts and was expanded, converting velocity energy largely to pressure energy. It was then dumped into the lower engine compartment, which acted as a plenum chamber. From here, the pressure energy was again converted to velocity as air flowed through the tightly baffled engine and then out through the cooling air exit directly in front of the propeller.

Early cooling tests confirmed our opinion that a cooling fan would not be required for ground operation. Heads, barrels, and oil remained well below allowable limits. Flight results were not so satisfactory: oil, barrels, and one cylinder head were all over limits.

Flight-test procedure for checking temperatures was to stabilize all temperatures in level flight at the lowest practical altitude and then climb at full throttle at the speed for best rate of climb. Stabilization temperatures were running high—in fact, much higher than seemed reasonable. The airplane was instrumented with pressure manometers, and flights to investigate

pressure distribution throughout the system were begun. One thing that immediately attracted our attention was the static pressure in the lower engine compartment (under baffle pressure). At lower speeds, pressure recovery was good (better than 80 per cent of free-stream dynamic pressure), but at 100 m.p.h. the pressure dropped sharply to a value below 70 per cent of free-stream dynamic pressure. It was suggested that perhaps air was spilling from the air-duct intake at the lower angles of attack that accompanied the higher speeds. Consequently, the front portion of the air duct was tufted internally (fortunately, the duct was easily visible to the pilot), and flight tests showed this supposition to be true. At 75 m.p.h., the tufts inside of the duct were steady; at 80, they began to fluctuate; and, at 90, they were fluctuating badly. At 100 m.p.h., the tufts on the lower lip of the duct completely reversed, indicating that the flow was outward rather than inward.

Extending the inboard end of the triangular duct forward 3 in. completely cured this flow reversal. Static pressure recovery was over 80 per cent of free-stream dynamic pressure for all flight attitudes.

Although cooling was improved, it was still far from satisfactory. Since additional improvement of pressure recovery on the upstream side of the baffles did not seem practical, an attempt was made to decrease the energy loss at the baffle exits. To do this, expanding ducts or pipes were attached to the baffle exits and carried the cooling air from the cylinders all of the way to the cooling air exit in front of the propeller. Air velocity measurements between cylinder fins showed that the flow was improved considerably, but strangely enough neither head nor barrel temperatures were lowered. The only explanation that can be offered for this is that the flow was essentially low turbulent, and increasing the flow by the use of tailpipes did nothing to increase the turbulence or scrubbing action required for efficient cooling.

At this stage of the experimentation it was felt that too much emphasis had been placed on pressure cooling. A higher duct flow rate seemed desirable, and it seemed that additional airflow over the accessory section and engine crankcase might do a lot to reduce oil and barrel base temperatures. A gap was cut in the vertical engine baffle that surrounds the engine accessory section. This change was believed to have reduced oil and barrel temperatures, but, because of faulty thermocouples, we were not able to prove it at that time. It was, however, confirmed by later tests on the first production airplane.

Unfortunately, the baffling system had become complicated by this time, so it was decided to start over. The engine was flown first without any baffles, and baffles were then added a piece at a time to find the minimum required for good distribution and efficient cooling. A considerable saving was made in complexity.

As a check on velocity cooling, a 2-in. flexible metal tube was faced into the air stream and directed onto a cylinder head that was giving trouble in cooling. This simple experiment reduced the head temperature approximately 50°.

Continental Motors suggested using a blast tube (similar to the one previously described) to direct air against the casting that housed the engine oil screen. They pointed out that the oil-flow velocity was extremely high at this point and that other manufacturers had been able to drop oil temperatures 5° to 7° by doing this. This was done with excellent results. In addition, an oil cooler was installed which attached directly to the engine accessory case and which further lowered the oil temperature. This cooler, however, required another blast tube. Without it, no temperature difference could be noted.

Results of all of these experiments indicated that the cooling problem on the AG-14 was susceptible to solution without much more work, and cooling tests were suspended until the new production airplane was ready.

Final Cooling Tests

Cooling tests on the production airplane provided the opportunity of quantitatively evaluating many of the cooling experiments previously discussed. Data were recorded using C.A.A. temperature equipment, and careful flight tests were conducted to eliminate error due to technique. As a check, several confirmation flights were made during the tests to see that data could be repeated from one test to the next.

Results of these tests are shown in Table 1. Tests were initiated with a tight baffle system around the cylinders and the engine accessory section. The oil cooler, together with its blast tube, was installed, as was the blast tube on the oil screen housing. A small deflector for directing air on No. 1 cylinder head was installed in the left-hand air duct. Results from this configuration are tabulated in the table. Cylinders are numbered starting at the front of the airplane and going aft to the propeller end. Numbers 1 and 3 are on the left-hand side of the airplane, and Nos. 2 and 4 are on the right-hand side. No data are presented for the right-hand cylinders because they tended to run slightly cooler than No. 3 cylinder.

Because No. 1 cylinder was running somewhat hotter than the others, the deflector that directed air to it was moved slightly aft in order to better direct the airflow (No. 1 cylinder was the only one that required a deflector). This modification reduced the temperature 42° but raised the temperature of No. 3 cylinder, which was directly behind it, 12°. The second modification was to cut a hole in the lower part of the engine cowl to improve the flow rate through the ducts and to increase the turbulence of the cooling air. This change had an appreciable effect on oil temperature and also lowered the heads and barrels slightly. The barrels were still running fairly high, so a cutout was made in the vertical baffle that surrounds the accessory section in the region between the upper engine mounting bosses.

TABLE 1
Summary of Results—Cooling Change with Configuration Modification

	100° Day Corrected Temperature and Temperature Change, ° F. (−) Indicates Cooler						
	Oil	No. 1 Barrel	No. 3 Barrel	No. 1 Upper Head	No. 1 Lower Head	No. 3 Upper Head	No. 3 Lower Head
INITIAL CONFIGURATION Tight-fitting baffles, oil cooler and oil cooler blast tube, oil screen housing blast tube, duct deflector on No. 1 cylinder	224	282	...	494	513	490	496
MODIFICATIONS							
(1) Duct deflector No. 1 cylinder moved aft	—	−3	...	−14	−42	−2	+12
(2) Vent hole cut in lower cowl	−9	−2	...	−5	−14	−4	−14
(3) Vent passage cut in vertical baffle between upper engine mount bosses	−12	−15	...	−5	−15	−1	−30
(4) Oil cooler and oil cooler blast tube removed	+18	+10	...	+2	−1	+3	+25
TOTAL CHANGES	−3	−10	...	−22	−72	−4	−7
FINAL TEST VALUES	221	272	270	472	441	486	489
ENGINE AND C.A.A. MAXIMUM ALLOWABLES	225	275	275	525	525	525	525

This modification significantly lowered barrel and oil temperatures and, in addition, appreciably lowered the head temperature of No. 3 cylinder.

Since the oil cooler was heavy and expensive, it was decided to eliminate it if possible. Results of the above changes had dropped the oil temperature 21° to a maximum of 203°. This gave a 22° margin below the maximum allowable temperature of 225°. These results are also shown in Table 1 and proved that an oil cooler would not be required.

We were very much interested in the quantitative effect of the blast tube on the oil screen housing, so one additional flight was made to evaluate it. Results of this test showed that this installation alone reduced oil temperature by 16°.

These changes completed the work in connection with cooling, and the system easily passed the requirements of the Civil Air Regulations.

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Helicopters— Present and Future

by
IGOR I. SIKORSKY*
United Aircraft Corporation

U.S. Army Photo

NOT LONG AGO it was usually taken for granted that heavier-than-air craft would always need a certain minimum speed in order to stay in the air and that maximum velocity would forever be limited by a figure somewhat below the speed of sound. The continued progress in aeronautical science has permitted us, within the last decade, to shatter both above-mentioned barriers. On the upper end of the scale, the meteoric jet-driven and rocket-driven airplanes, which travel at the speed at which only cannon shells were moving a few decades ago, may represent one of the most brilliant and spectacular achievements of human genius.

Much less spectacular, but perhaps equally important to humanity, has been the elimination of the lower barrier. This was accomplished by the helicopter, whose characteristics and ability of direct ascent, motionless hovering, slow speed, etc., opened a new and immensely important field of usefulness for aircraft in peace, as well as in war.

The value of the helicopter in war has been anticipated by many specialists. However, it has for the first time been indisputably demonstrated and proved during the recent war in Korea (see Fig. 1). The details of the operation of the few helicopters, mostly of our make, which participated in this war are generally known; therefore, in this discussion we will only mention a few statements that the military leaders have made recently on this subject.

Lieutenant General Lemuel C. Shepherd, Jr., Commanding General of the Pacific Fleet Force, who used one of our helicopters to make the first landing on Kimpo airfield after its liberation said:

> "Marine Corps helicopters in Korea are adding a new chapter to the history of military science. . . . .
> "There are no superlatives adequate to describe the general reaction to the helicopter. . . . ."

Presented at the New York Section Meeting, I.A.S., New York, November 9, 1950.

* Engineering Manager, Sikorsky Aircraft Division.

Lieutenant Gustave Lueddeke, U.S.M.C., helicopter pilot in the thick of Korean operations says:

> "One of the greatest contributions these things (helicopters) have made in war. . . .is to Marine morale. Every kid down there knows that, no matter what happens, we will get him out if he gets hit."

Major General Merwin Silverthorn, Acting Commandant of the Marine Corps, speaking before Vinson's subcommittee of the House Armed Services Committee, testified:

> "One of the four big lessons learned from the Korean War is that the use of the helicopter is practicable."

Major General Frank A. Heileman, Army Chief of Transportation, stated:

> "The Korean War has boomed the use of the helicopter. The Army is organizing helicopter companies for aerial distribution of supplies to isolated units. They will be of particular value to troops in mountain fighting. They will take the burden off the mule."

Brigadier General Edward A. Craig, First Marine Division, declared recently:

> "Any military force without them (helicopters) is back in the days of the Civil War."
> (NOTE: General Craig himself helped hoist a downed Marine pilot from the sea in a Sikorsky helicopter.)

A complete list of similar statements would run into a good-sized volume. The foregoing quotations give the flavor of awakened consciousness to the helicopter's military value.

The subject of the present discussion is vast. Therefore, in the attempt of analyzing the present and forecasting the future, we will limit the discussion to the subjects of size, speed, and configuration.

With regard to size, it seems to be certain that helicopters carrying from 20 to 40 people can be designed and constructed at the present time. Much larger machines of between 50,000 and 100,000 lbs. gross weight are well within reach and can be con-

U.S. Army Photo

FIG. 1. Sikorsky HO3S helicopter brings wounded to a Korean harbor.

structed in the near future as soon as there are requests for them.

There exists a considerable variety of opinion as to the preferable type and configuration of these large machines. There are also different opinions as to the best methods of applying power to their rotors. This may be by the use of conventional transmissions, by jets mounted at the tips of the blades, or by small auxiliary propellers and probably by other methods. In fact, aircraft utilizing all three above-mentioned methods have already been in the air. Only more extensive study will show which method could definitely be considered the best. However, I believe that, up to 100,000 lbs. and probably substantially beyond that figure, the conventional transmission-driven helicopter may still give satisfactory results and probably will remain the most efficient type.

With respect to speed, there is undoubtedly a fairly narrow limit to the velocity of a conventional type of helicopter. However, a convertible aircraft that in one way or another would, in flight, become transformed partly or entirely into an airplane could obviously develop much higher velocities. Therefore, helicopters flying at 200 or 300 m.p.h. and much faster are well within reach of present aeronautical science. However, craft of this type will always be much less efficient than either a pure airplane or pure helicopter using the same power. Consequently, I believe their use would be somewhat limited and that, for most of the objectives of military as well as commercial nature, the conventional helicopter, perhaps accelerated to some 150 or 200 m.p.h. by the addition of small wings and propellers, will remain the basic type in use.

Considerable diversity of opinion exists among engineers and students on the subject of the best configuration. The preference of a single rotor or tandem or some other configurations is debated and promoted with determination and enthusiasm. I still believe that, all around, the single rotor represents the best configuration for the helicopter because of factors that are similar to the ones that influenced the design of the airplane. The beginning of aviation saw biplanes, tandems, triplanes, etc. Finally, all multiwing types became eliminated and the monoplane alone survived because, in spite of the definite structural disadvantages, the aerodynamic efficiency of a single wing operating in unobstructed air is so great as to justify this type. I am convinced that the case will be similar with the helicopter. It must indeed be added that an idea of this nature should not be accepted dogmatically and there may be room for other configurations according to special missions that the aircraft may be requested to serve.

The summer of 1950 may definitely be considered as the time when the helicopter reached its full maturity and when its military usefulness had been demonstrated beyond any trace of doubt. The commercial usefulness had already been demonstrated earlier, even though on a small scale, by the 3 years of uninterrupted flight service of the Los Angeles air-mail operation and by other successful applications.

The helicopter is the most universal vehicle of travel ever created or used by man. Every other vehicle that we can think about is limited either by the nature of the road or surface over which it travels or, as in the case of the airplane, by an elaborate and large platform for departure and arrival. The helicopter alone, particularly if mounted on floats, is virtually independent from the nature of ground or water for its departure and landings and obviously can travel in any direction. These outstanding characteristics will assure to the helicopter a fundamentally important place in peace and in war.

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Some Roll Characteristics of Cruciform Delta Wings at Supersonic Speeds

By
Zegmund O. Bleviss
Douglas Aircraft Company, Inc.

Three roll problems associated with a missile-type configuration having a body of circular cross section, a cruciform delta wing, and some unspecified type of tail are considered. They are (1) roll due to aileron deflection of two opposite fins, (2) damping in roll, and (3) roll induced by pitch and yaw. Some effects of fin-fin, wing-body, and wing-body-tail interference are included.

Some theoretical solutions are presented for the roll due to aileron deflection and damping in roll. These results show clearly the effects of fin-fin and wing-body interference. Theoretical calculations for the cross-flow field in the Trefftz-plane behind a cruciform wing with aileron deflection are presented for the two different assumptions of nondistorted and completely rolled up vortex sheets.

A general qualitative discussion of these problems is presented. Effects of high angles of attack are discussed, along with some nonlinear, viscous, and gap effects.

Recommendations are made for future theoretical and experimental research.

Preprint No. 303

The Secondary Flow in a Cascade of Airfoils in a Nonuniform Stream

By
H. B. Squire and K. G. Winter
Royal Aircraft Establishment, England

A method is given of calculating the secondary flow in a cascade of airfoils in a stream with a variation of approach velocity along the span of the airfoils. The results are compared with measurements of the secondary flow at a cascade at a corner in a return-circuit wind tunnel, where the velocity gradient is obtained as a normal consequence of flow through a diffuser. The agreement between theory and experiment is satisfactory and indicates that the theory is sound.

Effects of Pressure Gradient on Stability and Skin Friction in Laminar Boundary Layers in Compressible Fluids

By
Herschel Weil
General Electric Company

An extension of the von Kármán-Pohlhausen method is carried through to find approximate steady-state velocities and temperatures in the compressible laminar boundary layer with a pressure gradient in the direction of flow along a two-dimensional adiabatic wall. These are used to find the effect of pressure gradient on skin friction, on momentum thickness, and, by a criterion due to Lees, on stability to small perturbations.

At a given point along the airfoil the boundary layer is stable if the Reynolds Number R_θ based on momentum thickness is less than a certain critical value $(R_\theta)_{cr.\ min.}$ which is a function solely of Mach Number M and a suitable parameter λ dependent on the airfoil shape. A curve family of $(R_\theta)_{cr.\ min.}$ vs. λ and vs. M's is given. In addition, the product of skin friction times R_θ which depends solely on λ is plotted. Numerical results were obtained for flows at $M = 1.5$ and 4 over a 5 per cent thick biconvex airfoil which showed that, for these examples, the favorable effect of the negative pressure gradient on stability is not large for $M = 4$ but is extremely pronounced at the lower supersonic Mach Number $M = 1.5$, and, in both cases, there is an increase in drag up to about 3 per cent at midchord compared to the case of a flat plate. The dependence on M and λ of the conversion factors between Reynolds Numbers based, respectively, on distance from the leading edge x, on momentum thickness θ, and on displacement thickness δ^* is exhibited.

The Laminar Boundary Layer on a Rotating Blade

By
Laurence Eugene Fogarty
Cornell University

Although the boundary-layer theory formulated by L. Prandtl in 1904 is of great importance in practical aerodynamics, the difficulties presented by the nonlinear boundary-layer equations have limited the classes of solutions to flows of special symmetry. Most of the cases that have been treated to date are two-dimensional in character; solutions of three-dimensional boundary-layer flows are rare.

One of the practically important types of three-dimensional boundary-layer flows is the flow on rotating blades, such as turbine, helicopter, and propeller blades. In this case, the centrifugal and Coriolis forces due to rotation, combined with the pressure gradients and viscous forces, cause the flow to be three-dimensional even in the absence of effects of finite span. von Kármán's solution of the problem of an infinite rotating disc is probably the only solution of a problem of this type.

As part of a program of investigation of three-dimensional boundary-layer flows, the laminar flow over a rotating cylindrical blade is treated here. Although the present investigation deals only with that portion of a blade of infinite span which is several chord lengths from the axis of rotation, it is believed that the results are of considerable interest. The results should be directly applicable, to good approximation, over a large portion of the span of high-aspect-ratio blades. Furthermore, it appears that treatment of the problem of a finite blade, or of a blade in the presence of a wall, for example, will make use of the results of the present investigation.

Coupled Free Vibrations of a Swept Wing

By
A. E. Engelbrecht
North American Aviation, Inc.

This paper presents a method by which the natural frequencies of the coupled free vibrations of a swept wing can be approximately determined.

The continuous elastic structure of the actual swept wing is approximated by a composite wing consisting of a finite number of sections. Each section contains a concentrated mass located at the outboard end of the section and an inboard weightless elastic bar of either straight or circular arc plan form. The choice as to whether the straight or circular arc bar is used in any section is determined by whichever form more nearly coincides with the locus of elastic centers of the section.

The usual assumptions of thin bar theory are made. Loads other than inertial loads are neglected, and the elements of the sections are assumed to be in harmonic motion.

A set of six equations is developed for each section. Each equation relates a shear bending moment, slope, deflection, torque, or angle of twist at the inboard end of a section to the shear bending moment, slope, deflection, torque, and angle of twist at the outboard end. The six relationships are then combined into a single matrix equation for each section.

A trial frequency is then substituted into each of the section matrices, and by successive matrix multiplication a single matrix for the entire wing semispan is obtained. If the trial frequency chosen is a natural frequency, the boundary conditions will be satisfied. If the boundary conditions are not satisfied, additional trial frequencies must be tried. Methods for determining proper frequency choices are shown, together with a numerical example in the paper.

High-Efficiency Supersonic Diffusers

By

E. P. Neumann and F. Lustwerk

Gas Turbine Laboratory, Massachusetts Institute of Technology

Supersonic diffusers having a variable throat were designed with wind-tunnel application in mind. The test results indicate that a stagnation pressure recovery of 79 per cent at $M = 2.22$ and 53 per cent at $M = 2.92$ can be obtained without boundary-layer suction. These values can result in an operating power reduction of 60 per cent over conventional design at $M = 2.22$.

The effect of scale on diffuser performance is discussed. Design parameters for a diffuser design are given.

The Decay of Isotropic Temperature Fluctuations in an Isotropic Turbulence

By

Stanley Corrsin

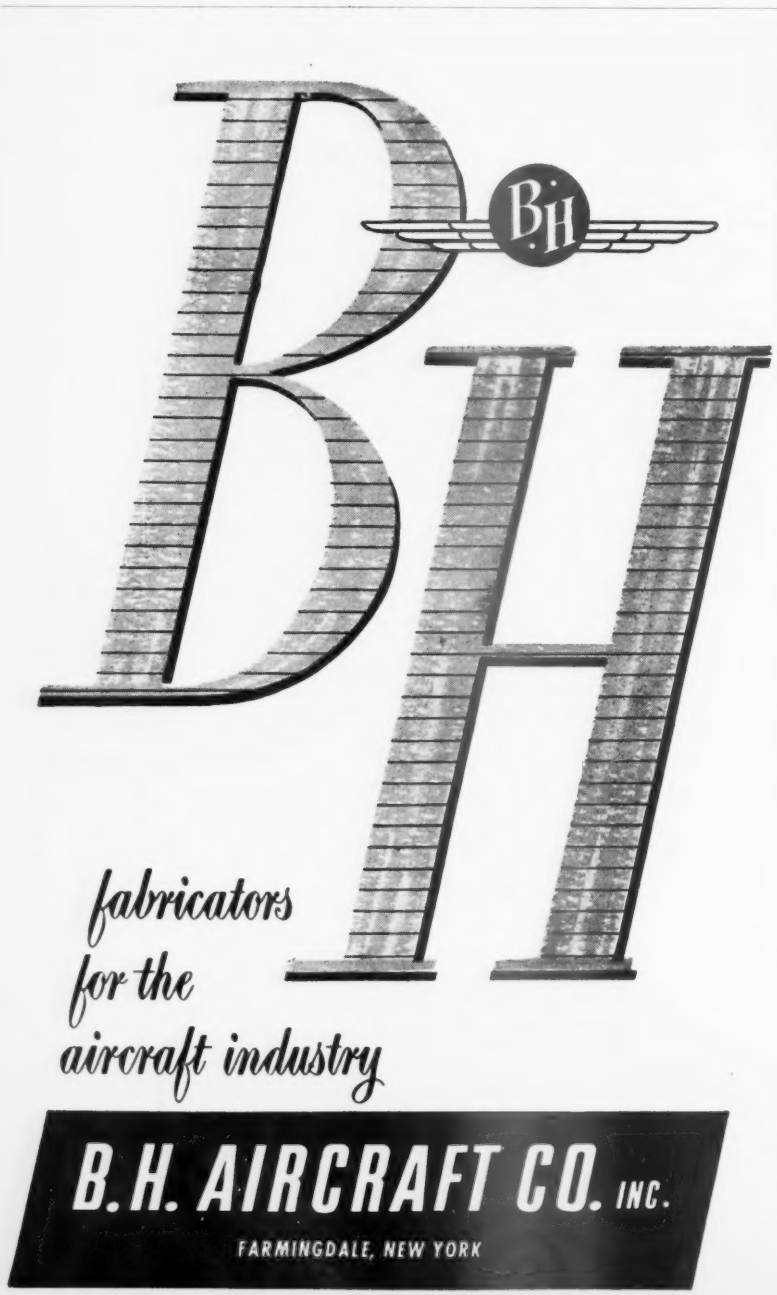
The Johns Hopkins University

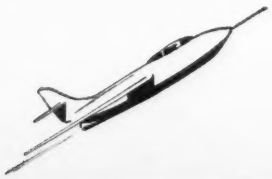
The approach of von Kármán and Howarth (to isotropic turbulence) has been applied to the decay of isotropic temperature fluctuations in a decaying isotropic turbulence, under the restriction that the temperature differences are too small to have any effect on the velocity field.

From the correlation equation it is found that, if the scalar functions characteristic of the pertinent double and triple correlations are assumed to descend to zero faster than r^{-2}, the product of the second moment of the double temperature correlation coefficient and the mean square temperature fluctuation is a constant during decay. This is analogous to Loitsiansky's "theorem" for the constancy of the product of turbulent energy and fourth moment of the velocity correlation coefficient in the turbulence decay.

For extremely small Péclet Number the correlation equation reduces to the three-dimensional heat conduction equation with spherical symmetry. The corresponding equation for the linear viscous decrement of the velocity field is a quasi-five-dimensional equation.

Estimates of decay and scale growth of the temperature fluctuations at both extremely small and extremely large Péclet Numbers are compared with the corresponding results for the turbulence. Perhaps the most practical result is that the temperature "spottiness" seems always to die off at a slower rate than the velocity "spottiness."





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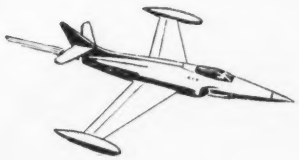

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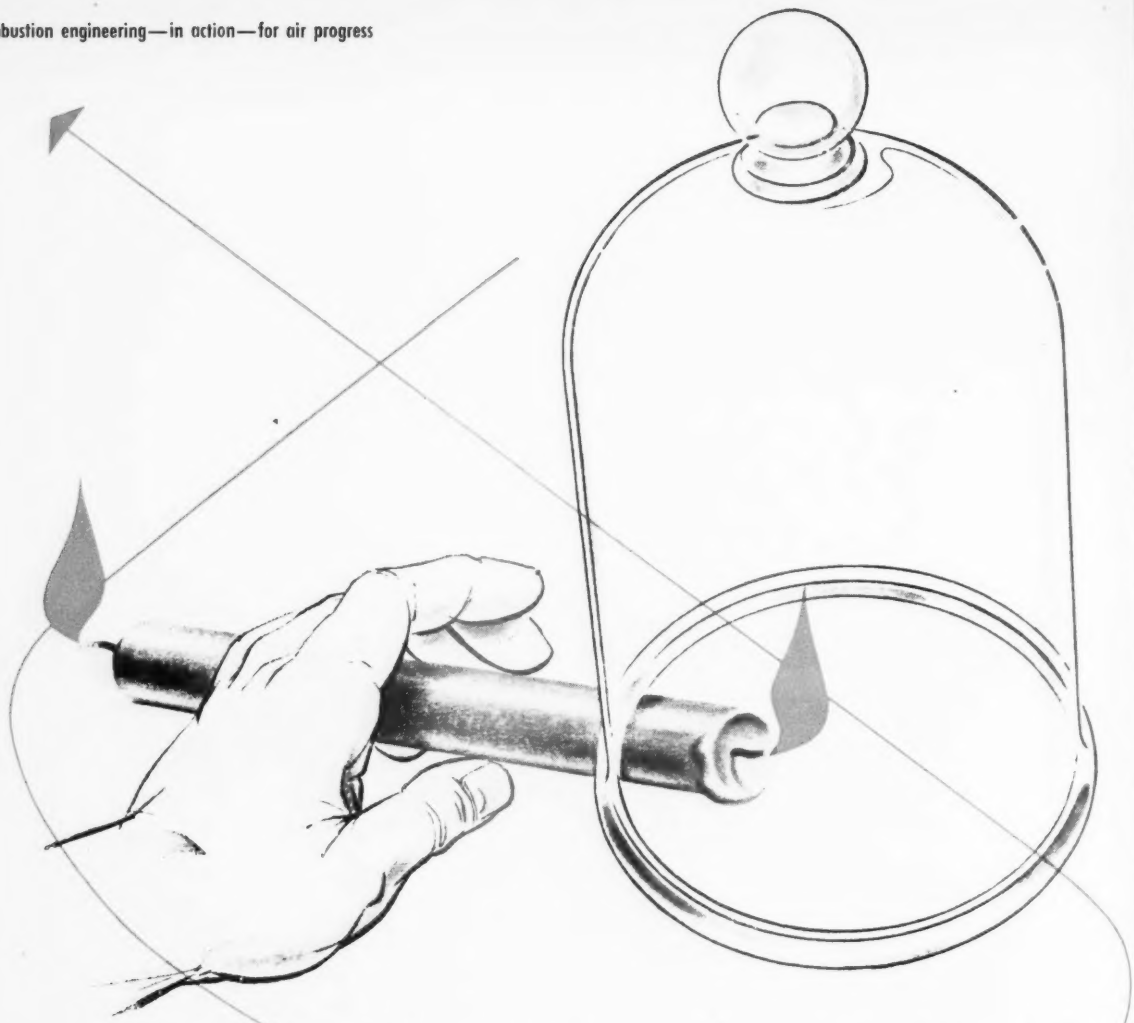

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Aeronautical Reviews

A Guide to the Current Literature of Aeronautical Research and Engineering

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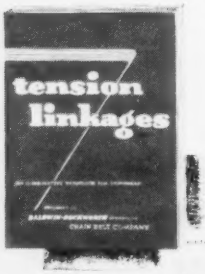

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Aerodynamics (2)

BOUNDARY LAYER

On a Solution of the Laminar Boundary-Layer Equation near a Position of Separation. C. W. Jones. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 1, Part 4, December, 1948, pp. 385–407, illus. 3 references.

On Laminar Boundary-Layer Flow near a Position of Separation. S. Goldstein. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 1, Part 1, March, 1948, pp. 43–68. 6 references.

Readers' Forum: Calculation of the Thermal Boundary Layer of a Body in Incompressible Laminar Flow. W. Dienemann. *Journal of the Aeronautical Sciences*, Vol. 18, No. 1, January, 1951, pp. 64, 65, illus. 9 references.

A Solution of the Laminar Boundary-Layer Equation for Retarded Flow. D. R. Hartree. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2426*, 1949 (March 28, 1939). 27 pp., illus. 16 references. British Information Services, New York. $1.25.

Reflection at a Laminar Boundary Layer of a Weak Steady Disturbance to a Supersonic Stream, Neglecting Viscosity and Heat Conduction. M. J. Lighthill. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 3, Part 3, September, 1950, pp. 303–325, illus. 6 references.

Analysis of Turbulent Free-Convection Boundary Layer on Flat Plate. E. R. G. Eckert and Thomas W. Jackson. *U.S., N.A.C.A., Technical Note No. 2207*, October, 1950. 22 pp., illus. 9 references.

The flow and heat transfer for a fluid with a Prandtl Number close to unity was calculated by the use of von Kármán's approximate method. Formulas are derived for the heat-transfer coefficient, for the maximum velocity in the boundary layer, and for the boundary-layer thickness.

Note on the Velocity and Temperature Distributions Attained with Suction on a Flat Plate of Infinite Extent in Compressible Flow. A. D. Young. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 1, Part 1, March, 1948, pp. 70–75, illus. 2 references.

The Solution of the Equations of the Laminar Boundary Layer for Schubauer's Observed Pressure Distribution for an Elliptic Cylinder. D. R. Hartree. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2427*, 1949 (April 4, 1939). 30 pp., illus. 13 references. British Information Services, New York. $1.25.

Note on the Circulatory Flow About a Circular Cylinder Through Which the Normal Velocity Is Large. B. Thwaites. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 3, Part 1, March, 1950, pp. 74–79. 3 references.

Investigation of radial symmetric flow outside a fixed porous cylinder of infinite length on which is superposed a distribution of circulation. An exact solution for steady flow is given in finite terms; no exact solution exists for unsteady flow. General solutions are found in the form of asymptotic series in a parameter involving the suction velocity from which the velocity and pressure fields and torque can be found for cases where no general solution exists. The solutions are analogous to conventional boundary-layer theory.

A Comparison of Three Thick, Symmetrical, Multi-Slot Suction Aerofoils. N. Gregory and A. R. Curtis. *Gt. Brit., Aeronautical Research Council, Current Papers No. 20*, 1950 (October 1, 1948). 9 pp., illus. 4 references. British Information Services, New York. $0.30.

Comparison of the Tadpole IX (33.4 per cent thick) and Tadpole XIII (30.4 per cent thick) airfoils, which have velocity discontinuities over the forward portion of the airfoil, with a 30 per cent thick Griffiths airfoil. The suction quantities and ideal effective C_D are higher for the Tadpole airfoils than for the Griffith section. For similar regions of laminar and turbulent flow, the drag and suction quantities are less if fewer slots are used. Large drag reductions may be obtained by sucking away the turbulent boundary layer near the nose if the turbulent layer is replaced by a laminar layer.

The Indication of Boundary-Layer Transition on Aerofoils in the N.P.L. 20 In. × 8 In. High Speed Wind Tunnel. H. H. Pearcey. *Gt. Brit., Aeronautical Research Council, Current Papers No. 10*, 1950 (December 14, 1948). 13 pp., illus. 8 references. British Information Services, New York. $0.35.

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Note on the Increase of Drag of an Aerofoil Due to the Thickening of the Boundary Layer Behind a Shock Wave. A. D. Young and E. Young. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2401*, 1950 (August, 1946). 3 pp., illus. 3 references. British Information Services, New York. $0.30.

Calculations of the theoretical C_D of EC 1250 and Mustang airfoil sections at $M = 0.79$ and $R = 10^6$. The increase in C_D due to boundary-layer thickening caused by the shock wave is approximately 0.001, which is less than the drag increase usually associated with the development of shock waves.

The Application of Boundary-Layer Theory to Swirling Liquid Flow Through a Nozzle. A. M. Binnie and D. P. Harris. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 3, Part 1, March, 1950, pp. 89–106, illus. 6 references.

Derivation of the laminar boundary-layer equations for flow from a high-pressure reservoir when the main stream of the liquid possesses both swirl and axial velocity. The axial velocity is uniform over the cross section; it attains a value at the throat equal to the velocity of a long wave moving axially on the spinning surface of the core. The equations are solved to give estimates of the thickness of the boundary layer and the discharge through it.

The Boundary Layer in the Converging Nozzle of a Swirl Atomizer. G. I. Taylor. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 3, Part 2, June, 1950, pp. 129–139, illus. 2 references.

The study of boundary layers that contain both swirl and axial velocity. An approximate analysis of the case with the solid at rest and the liquid rotating, or swirling in a free vertex, is based on Pohlhausen's use of the momentum integrals through the boundary layer. The growth of the boundary layer is examined, and the velocity with which the fluid layer flows toward the vertex is calculated.

CONTROL SURFACES

Equations and Charts for the Rapid Estimation of Hinge-Moment and Effectiveness Parameters for Trailing-Edge Controls Having Leading and Trailing Edges Swept Ahead of the Mach Lines. Kenneth L. Goin. *U.S., N.A.C.A., Technical Note No. 2221*, November, 1950. 92 pp., illus. 10 references.

Flight Tests to Investigate the Lightness of an Unbalanced Elevator on the Lockheed 12A. M. B. Morgan and D. E. Morris. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2372*, 1949 (January, 1940). 14 pp., illus. 5 references. British Information Services, New York. $0.75.

The Aileron. Robert McLarren. *Aero Digest*, Vol. 61, No. 5, November, 1950, pp. 93, 95–100, 102–105, illus. 24 references. Review of aileron theory; effects of spoiler devices and swept wings on aileron performance; trends for future research.

An Approximate Method for the Determination of the Increase of Maximum Lift on Thin Profiles Due to Trailing Edge Flaps. H. O. Palme and S. Stark. *Sweden, Kungl. Tekniska Högskola, Institution for Flygteknik, Technical Note No. KTH—AERO TN 18*, 1950 (April 25, 1948). 9 pp., illus. 1 reference. In English.

The method is based on the assumption that the forward stagnation point has a limiting rear position on the lower surface; this limit is not changed by the deflection of the flap.

Investigation in the Langley 19-Foot Pressure Tunnel of Two Wings of NACA 65-210 and 64-210 Airfoil Sections with Various Type Flaps. James C. Sivells and Stanley H. Spooner. *U.S., N.A.C.A., Report No. 942*, 1949. 23 pp., illus. 3 references. U.S. Govt. Printing Office, Washington. $0.25.

Aerodynamic Coefficients for an Oscillating Airfoil with Hinged Flap, with Tables for a Mach Number of 0.7. M. J. Turner and S. Rabinowitz. *U.S., N.A.C.A., Technical Note No. 2213*, October, 1950. 46 pp., illus. 9 references.

FLUID MECHANICS & AERODYNAMIC THEORY

The Energy Distribution Behind Decaying Shocks. M. J. Lighthill. *Philosophical Magazine*, Vol. 41 (7th Series), No. 322, November, 1950, pp. 1101–1128. 15 references.

The degree of accuracy of Friedrich's theory of the decaying of plane shocks is examined through a consideration of the energy balance assuming arbitrary thermodynamic properties for the fluid. By a series of checks, it is determined that the Friedrichs theory describes the final stage of decay accurate to only the first approximation, but the front shock correctly to a second approximation.

Approximate Solutions for Shock Waves in a Steady, One-Dimensional, Viscous and Compressible Gas. Paul Lieber, Frank Romano, and Henry Lew. *Journal of the Aeronautical Sciences*, Vol. 18, No. 1, January, 1951, pp. 55–60, illus. 3 references.

The Position of the Shock-Wave in Certain Aerodynamic Problems. M. J. Lighthill. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 1, Part 3, September, 1948, pp. 309–318. 3 references.

Formulas and Tables of Coefficients for Numerical Differentiation with Function Values Given at Unequally Spaced Points and Application to Solution of Partial Differential Equations. Chung-Hua Wu. *U.S., N.A.C.A., Technical Note No. 2214*, November, 1950. 104 pp., illus. 15 references.

In the application of the tables to elliptic equations, the derivatives are replaced by formulas based on fourth-degree polynomials, and the equations are solved by the relaxation and matrix methods. The application is extended to problems of compressible flow past airfoils, airfoil cascades, and turbines.

On the Hodograph Transformation for High-Speed Flow. I—A Flow Without Circulation. S. Goldstein, M. J. Lighthill, and J. W. Craggs. **II—A Flow with Circulation.** M. J. Lighthill. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 1, Parts 3, 4, September, December, 1948, pp. 344–357; 442–450, illus. 9 references.

On the Linearized Potential Theory of Unsteady Supersonic Motion. K. Stewartson. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 3, Part 2, June, 1950, pp. 182–199. 6 references.

The Laplace transformation is applied to several problems of unsteady supersonic flow, assuming that the approximations of the linearized potential theory are valid. Simple expressions for the lift distributions on the semi-infinite wing, the sweptback wing, and the slender body of revolution at incidence are obtained. A method for obtaining a power series for the lift on a delta wing is also given.

Graphical Method for Obtaining Flow Field in Two-Dimensional Supersonic Stream to Which Heat Is Added. I Irving Pinkel and John S. Serafini. *U.S., N.A.C.A., Technical Note No. 2206*, November, 1950. 62 pp., illus., 2 fold. charts. 3 references. The charts cover a Mach Number range of 1.3–5.0.

On Source and Vortex Distributions in the Linearized Theory of Steady Supersonic Flow. A. Robinson. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 1, Part 4, December, 1948, pp. 408–432, illus. 9 references.

The Numerical Method of Characteristics for Supersonic Flows with Axial Symmetry. M. Holt. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 2, Part 4, December, 1949, pp. 473–478, illus. 2 references.

Anisotropy of the Spectrum of Turbulence at Small Wave-Numbers. G. K. Batchelor and R. W. Stewart. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 3, Part 1, March, 1950, pp. 1–8, illus. 3 references.

Experimental evidence of the comparison of two velocity correlations in the initial period of decay and the measurement of the turbulent energy distribution in the final period of decay show that a grid of bars in a uniform stream creates homogeneous turbulence in which the components of small wave number are anisotropic and remain so through the decay. These results agree with the theoretical analysis.

Supersonic Flow past a Semi-Infinite Cone. J. B. Broderick. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 2, Part 1, March, 1949, pp. 121–128. 4 references.

Readers' Forum: An Approximate Treatment of Multishock Bodies of Revolution at Small Angles of Attack by the Method of Characteristics. R. E. Bower. *Journal of the Aeronautical Sciences*, Vol. 18, No. 1, January, 1951, pp. 70, 71, illus. 2 references.

Supersonic Flow past Slender Pointed Bodies. G. N. Ward. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 2, Part 1, March, 1949, pp. 75–97, illus. 5 references.

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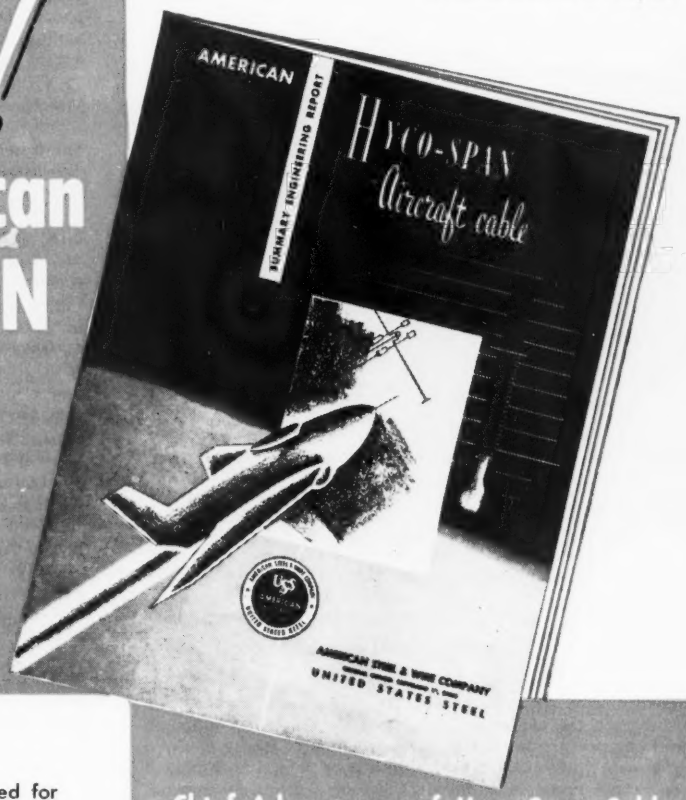

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Supersonic Flow Round Pointed Bodies of Revolution. J. B. Broderick. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 2, Part 1, March, 1949, pp. 98–120, illus. 6 references.

Supersonic Flow past Slender Pointed Bodies of Revolution at Yaw. M. J. Lighthill. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 1, Part 1, March, 1948, pp. 76–89. 2 references.

Supersonic Flow past Slender Bodies of Revolution the Slope of Whose Meridian Section Is Discontinuous. M. J. Lighthill. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 1, Part 1, March, 1948, pp. 90–102. 6 references.

On the Stability of Two-Dimensional Smooth Transonic Flow. Yung-Huai Kuo. *Journal of the Aeronautical Sciences*, Vol. 18, No. 1, January, 1951, pp. 1–6, 54, illus. 10 references.

The Steady Flow of Viscous Fluid past a Sphere and Circular Cylinder at Small Reynolds Numbers. S. Tomotika and T. Aoi. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 3, Part 2, June, 1950, pp. 140–161, illus. 8 references.

Investigation of the flow past a sphere and a circular cylinder on the basis of Goldstein's exact analytical solution to Oseen's linearized equations of motion to determine if the flow patterns observed experimentally can be reproduced theoretically. The drags of the bodies are examined, with emphasis on the pressure drag and frictional drag.

The Approximate External and Internal Flow past a Quasi-Cylindrical Tube Moving at Supersonic Speeds. G. N. Ward. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 1, Part 2, June, 1948, pp. 225–245, illus. 8 references.

A Note on the Hodograph Transformation for the Two-Dimensional Vortex Flow of an Incompressible Fluid. S. Goldstein and M. J. Lighthill. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 3, Part 3, September, 1950, pp. 297–302, illus. 5 references.

For the problem of irrotational motion in jets, the transformation from the physical to the hodograph plane is not a one-to-one transform; the hodograph plane is a Riemann surface. To demonstrate the occurrence of branch lines in the hodograph transformation, the hodograph plane is computed for the flow of a stream with uniform shear past a circular cylinder. Such branch lines cannot occur in irrotational subsonic flow. In general, branch lines are cusped in the hodograph plane.

Problems in the Theory of Viscous Compressible Fluids. Paco A. Lagerstrom, Julian D. Cole, and Leon Trilling. *California Institute of Technology, Guggenheim Aeronautical Laboratory*, October, 1950 (March, 1949). 232 pp., illus. 84 references. Durand Reprinting Committee, California Institute of Technology, Pasadena, Calif. $2.00.

The basis of a technique for dealing with linearized equations and examples of the use of this technique. The work deals chiefly with problems for a set of linearized equations of motion of a fluid with negligible heat conditions with two types of waves—longitudinal and transverse. The effects of viscosity and compressibility were investigated for the solutions for linear and nonlinear equations. The interaction between longitudinal and transverse waves is treated. Derivation of fundamental solutions for various cases is considered in the appendixes. In addition to this material, which was contained in the report published March, 1949, this reprint includes an errata to the original work, additional bibliographical material, and further discussion of flow past a flat plate.

The Method of Characteristics for Problems of Compressible Flow Involving Two Independent Variables. I—The General Theory (With a Note on the Calculation of Axially-Symmetrical Supersonic Flows). S. Goldstein. II—Integration Along a Mach Line; The Radial Focusing Effect in Axially Symmetrical Flow. R. E. Meyer. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 1, Parts 2, 4, June, December, 1948, 198–219; 451–469; illus. 21 references.

Non-Linear Character of Compressible Aerodynamics. Yosio Akita. *Japan Science Review (Engineering Sciences)*, Vol. 1, No. 2, June, 1950, pp. 5–10, illus. In English. Analysis of the fundamental equation of nonlinear compressible flow.

On Some General Theorems in the Linearized Theory of Compressible Flow. F. Ursell and G. N. Ward. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 3, Part 3, September, 1950, pp. 326–348, illus. 15 references.

Vector methods are used to demonstrate that the linearized theory for steady irrotational isentropic flow past a thin body with a sharp trailing edge is adequate for the calculation of the lift and drag on the body. Certain assumptions are required by the appearance of infinities at the edges of the wake. Relationships are found between the flow past a thin body and the reversed flow past the body.

Linearized Compressible-Flow Theory for Sonic Flight Speeds. Max A. Heaslet, Harvard Lomax, and John R. Spreiter. *U.S., N.A.C.A., Report No. 956*, 1950. 16 pp., illus. 21 references. U.S. Govt. Printing Office, Washington. $0.20.

Solutions that are in good agreement with linearized theory are found for stationary three-dimensional flow and unsteady two-dimensional flow. The flow conditions over several surfaces are determined when the free-stream Mach Number = 1.

Flow Patterns and the Method of Characteristics near a Sonic Line. M. Holt. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 2, Part 2, June, 1949, pp. 246–256, illus. 2 references.

The Behaviour of the Velocity Along a Straight Characteristic in Steady Irrotational Isentropic Flow with Axial Symmetry. M. Holt. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 1, Part 3, September, 1948, pp. 358–364, illus. 1 reference.

Eddy Diffusion and Evaporation in Flow over Aerodynamically Smooth and Rough Surfaces: A Treatment Based on Laboratory Laws of Turbulent Flow with Special Reference to Conditions in the Lower Atmosphere. K. L. Calder. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 2, Part 2, June, 1949, pp. 153–176. 22 references.

On a Family of Rotational Spatial Gas Flows. R. Prim and P. Neményi. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 2, Part 2, June, 1949, pp. 129–135. 6 references.

The Formation of Closed Wakes in Fluid Motions. D. N. de G. Allen. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 2, Part 1, March, 1949, pp. 64–71, illus. 5 references.

The Effect of Wire Gauze on Small Disturbances in a Uniform Stream. G. I. Taylor and G. K. Batchelor. **Appendix: National Bureau of Standards Measurements of Lateral Force on Gauzes of Round Wires.** H. L. Dryden and G. B. Schubauer. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 2, Part 1, March, 1949, pp. 1–29, illus. 8 references.

INTERNAL FLOW

Overall Performance Characteristics of a Four-Stage Reaction Turbine. D. G. Ainley, S. E. Petersen, and R. A. Jeffs. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2416*, 1950 (September, 1946). 20 pp., illus. 4 references. British Information Services, New York. $1.00.

Tests of a low-pressure turbine that consists of four stages of 50 per cent reaction blading, with cold pressurized air over a large portion of its working range. Test results are plotted and are compared with theoretical calculations.

The Supersonic Axial-Flow Compressor. Arthur Kantrowitz. *U.S., N.A.C.A., Report No. 974*, 1950. 9 pp., illus. 4 references. U.S. Govt. Printing Office, Washington. $0.25. Analysis of axial-flow compressors that have supersonic velocities in the blade rows.

A Theoretical Investigation into the Effect of Profile Shape on the Performance of Aerofoils in Cascade. A. D. S. Carter and Hazel P. Hughes. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2384*, 1950 (March, 1946). 39 pp., illus. 8 references. British Information Services, New York. $1.60.

Study of two-dimensional flow through a cascade by the method of conformal transformation. Calculations were carried out for six cascade types; results are tabulated and plotted. A deviation rule is given for parabolic-type airfoils. The correct choice of profile shape for airfoils in a cascade depends upon the duty a cascade must do. Airfoils with a thickness greater than 10 per cent give poor performance in a cascade.

Attainable Circulation About Airfoils in Cascade. Arthur W. Goldstein and Artur Mager. *U.S., N.A.C.A., Report No. 953*, 1950. 23 pp., illus. 13 references. U.S. Govt. Printing Office, Washington. $0.25.

A relationship is established between profile thickness, velocity diagram, Reynolds Number, maximum surface velocity, and solidity for a cascade of airfoils in two-dimensional incompressible fluid flow, and the effect of the cascade design parameters on cascade solidity is calculated.

Readers' Forum: On the Calculation of the Potential Flow Around Airfoils in Cascade. N. Scholz. *Journal of the Aeronautical Sciences*, Vol. 18, No. 1, January, 1951, pp. 68, 69, illus. 8 references.

An Experimental Investigation of Supersonic Lattice Flow. James E. O'Neill. *Aeronautical Engineering Review*, Vol. 10, No. 1, January, 1951, pp. 28–32, illus.

Velocity Distribution and Fluid Friction in Smooth Concentric Annuli. R. R. Rothful, C. C. Monrad, and V. E. Senecal. *Industrial and Engineering Chemistry*, Vol. 42, No. 12, December, 1950, pp. 2511–2520, illus. 21 references. The study of the isothermal flow of air at room temperature by the measurement of static pressure differentials and point velocities.

The Viscid Flow of Air in a Narrow Slot. G. L. Shires. *Gt. Brit., Aeronautical Research Council, Current Papers No. 13*, 1950 (December, 1948). 30 pp., illus. 1 reference. British Information Services, New York. $0.65.

Theoretical and experimental investigation of the properties of viscid flow of air in a rectangular slot that has a width large in comparison with its depth, considering both laminar and turbulent flows.

Suction Force on the Lip of a Two-Dimensional Idealized Scoop in Non-Viscous Subsonic Flow. Charles W. Coale. *Douglas Aircraft Company, Inc., Report No. SM-13742*, April 11, 1950. 17 pp., illus. 4 references.

Calculation of the suction-force coefficient on a scoop for incompressible and compressible flow. The coefficient decreases with mass-flow ratio and increases with Mach Number. The position of the stagnation point is determined for a thin-plate scoop in incompressible flow.

A Note on Prandtl's Formula for the Wave-Length of a Supersonic Gas Jet. D. C. Pack. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 3, Part 2, June, 1950, pp. 273–181. 9 references.

The mean velocity of the jet is found to be the velocity of the bounding streamlines, rather than the exit velocity, as assumed by Prandtl. With this correction, a better agreement exists between theoretical and experimental values for the wave length of cylindrical jets with sonic exit velocity. The theory is expected to have a wider range of application to jets with axial symmetry than to plane jets.

On the Formation of Shock-Waves in Supersonic Gas Jets (Two-Dimensional Flow). D. C. Pack. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 1, Part 1, March, 1948, pp. 1–17, illus. 9 references.

The Boundary Layer in the Converging Nozzle of a Swirl Atomizer. G. I. Taylor. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 3, Part 2, June, 1950, pp. 129–139, illus. 2 references.

The study of boundary layers that contain both swirl and axial velocity. An approximate analysis of the case with the solid at rest and the liquid rotating, or swirling in a free vertex, is based on Pohlhausen's use of the momentum integrals through the boundary layer. The growth of the boundary layer is examined, and the velocity with which the fluid layer flows toward the vertex is calculated.

Exact Solutions for Flow of a Perfect Gas in a Two-Dimensional Laval Nozzle. T. M. Cherry. *Royal Society (London), Proceedings, Series A, Mathematical and Physical Sciences*, Vol. 203, No. 1075, October 24, 1950, pp. 551–571, illus. 4 references.

Calculation of a family of exact solutions for steady irrotational isentropic shock-free transonic flow by the hodograph method. The position coordinates are expressed in terms of the velocity variables; the expressions are infinite series in the subsonic region and infinite integrals in the supersonic portion. Approximate formulas are derived for the region of sonic speed.

The Application of Boundary-Layer Theory to Swirling Liquid Flow Through a Nozzle. A. M. Binnie and D. P. Harris. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 3, Part 1, March, 1950, pp. 89–106, illus. 6 references.

Derivation of the laminar boundary-layer equations for flow from a high-pressure reservoir when the main stream of the liquid possesses both swirl and axial velocity. The axial velocity is uniform over the cross section; it attains a value at the throat equal to the velocity of a long wave moving axially on the spinning surface of the core. The equations are solved to give estimates of the thickness of the boundary layer and the discharge through it.

PARASITIC COMPONENTS & INTERFERENCE

Aerodynamic Interference in Supersonic Missiles. P. A. Lagerstrom and M. E. Graham. *Douglas Aircraft Company, Inc., Report No. SM-13743*, July, 1950. 92 pp., illus. 19 references.

Investigation of vortex-interference on a missile with low-aspect-ratio lifting surfaces and a small wing-span-fuselage-ratio diameter. Wing-fuselage interference and wing-fuselage-tail interference are studied. In the examination of wing-fuselage interference, slender-body theory is used, and corrections are applied to it from an estimation of planar systems that have exact linearized solutions and from a general consideration of low-aspect-ratio theory. For the problem of wing-fuselage-tail interference, the spanwise lift on the wing is calculated. A "rolled-up" vortex sheet is assumed. The vortex sheet is replaced by two vortex lines, and the downwash calculated from the position and flow field of the vortices.

Wind Tunnel Tests on a One-Twelfth Scale Model of a Twin-Engined Military Transport (Airspeed C 13/45 Ayrshire). R. Warden. *Gt. Brit., Aeronautical Research Council, Current Papers No. 17*, 1950 (January 13, 1949). 45 pp., illus. British Information Services, New York. $0.90.

Measurement of wing-body interference and longitudinal stability on a high-wing twin-engined transport aircraft with underslung nacelles. The wing and fuselage were tested separately, and the wing was tested with and without nacelles. Stability tests were run with and without operating propellers. There is an appreciable body interference effect on the tail; under climb conditions, slipstream has a considerable adverse effect on stability. C_L, C_D, and C_m are tabulated for the range of test conditions.

Suction Force on the Lip of a Two-Dimensional Idealized Scoop in Non-Viscous Subsonic Flow. Charles W. Coale. *Douglas Aircraft Company, Inc., Report No. SM-13742*, April 11, 1950. 17 pp., illus. 4 references.

Calculation of the suction-force coefficient on a scoop for incompressible and compressible flow. The coefficient decreases with mass-flow ratio and increases with Mach Number. The position of the stagnation point is determined for a thin-plate scoop in incompressible flow.

PERFORMANCE

The Influence of Wing Geometry and Structural Efficiency on Aircraft Performance. J. Solvey. (*Australia, Council for Scientific and Industrial Research, Division of Aeronautics, Report No. SM. 119*, October, 1948.) *Australia, Department of Supply, Aeronautical Research Consultative Committee, Report No. ACA-45*, March, 1949. 25 pp., illus. 2 references.

Investigation of the effect of wing plan form and thickness variation on wing-structure weight and aircraft performance with the use of the criterion of wing structural efficiency. Results are given in curves for four airplanes: fighter type, bomber type, and two civil transport types.

Note on the Relations Between Turning and Straight Performance. S. B. Gates. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2382*, 1950 (October, 1941). 7 pp., illus. 3 references. British Information Services, New York. $0.40.

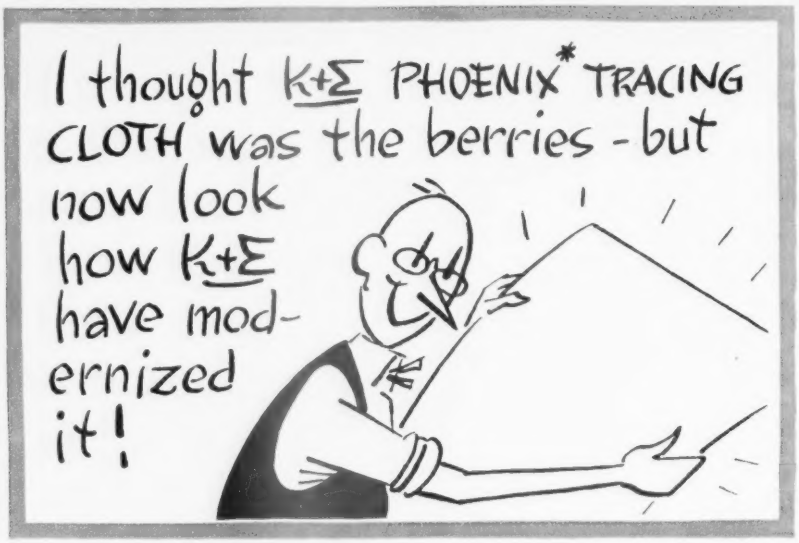
Present-Day Stalling Risks with Civil Aircraft. K. W. Clark. *Aircraft Engineering*, Vol. 22, No. 261, November, 1950, pp. 338, 339.

STABILITY & CONTROL

Nonlinear Effects of Structural Deformation on Stability. Albert Epstein. *Journal of the Aeronautical Sciences*, Vol. 18, No. 1, January, 1951, pp. 50–54, illus. 6 references. Analysis of the effect of skin buckling on longitudinal stability and its influence on control forces.

Longitudinal Stability, Speed and Height. S. Neumark. (*Gt. Brit., Royal Aircraft Establishment, Report No. Aero. 2265*, May, 1948.) *Aircraft Engineering*, Vol. 22, No. 261, November, 1950, pp. 323–334, illus. 21 references.

Investigation of dynamic longitudinal stability in level flight, including the effects of compressibility and changes in atmospheric phenomena with height. The effects of small variations in atmospheric density and speed of sound with height affect dynamic-longitudinal-stability increase with Mach Number. One result



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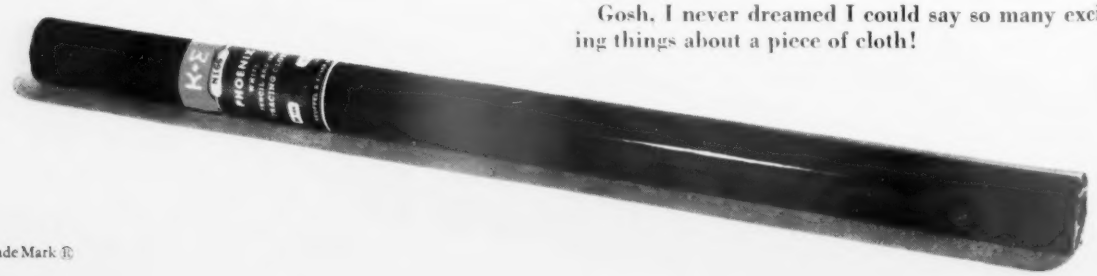

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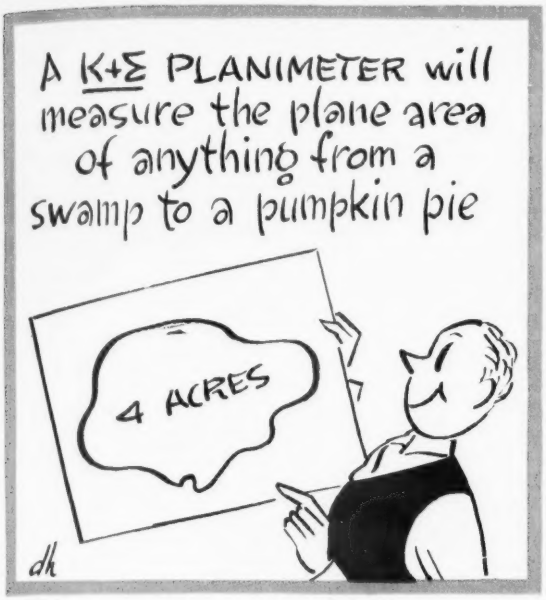

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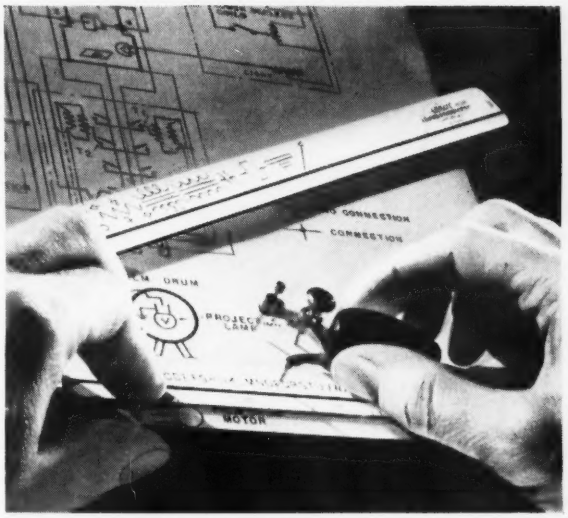

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of the investigation is the appearance of a new mode of disturbance which determines height instability or stability. This mode shows to what extent an aircraft is able to keep constant altitude over long periods of time.

Readers' Forum: Note on "Longitudinal Stability of Autopilot-Controlled Aircraft." G. J. Sissingh. *Journal of the Aeronautical Sciences*, Vol. 18, No. 1, January, 1951, p. 65.

Effect of Propeller Thrust on Downwash and Velocity at Tailplane; A Collection of Data from Low Speed Tunnel Tests. A. Spence. *Gt. Brit., Aeronautical Research Council, Current Papers No. 21*, 1950 (August, 1947). 19 pp., illus. 4 references. British Information Services, New York. $0.40. Data from low-speed wind-tunnel tests on the longitudinal stability of five propeller models are plotted and tabulated.

Some Effects of Nonlinear Variation in the Directional-Stability and Damping-in-Yawing Derivatives on the Lateral Stability of an Airplane. Leonard Sternfield. *U.S., N.A.C.A. Technical Note No. 2233*, November, 1950. 19 pp., illus. 3 references.

Wind Tunnel Tests on a One-Twelfth Scale Model of a Twin-Engined Military Transport (Airspeed C 13/45 Ayrshire. R. Warden. *Gt. Brit., Aeronautical Research Council, Current Papers No. 17*, 1950 (January 13, 1949). 45 pp., illus. British Information Services, New York. $0.90.

Measurement of wing-body interference and longitudinal stability on a high-wing twin-engined transport aircraft with underslung nacelles. The wing and fuselage were tested separately and the wing was tested with and without nacelles. Stability tests were run with and without operating propellers. There is an appreciable body interference effect on the tail; under climb conditions, slipstream has a considerable adverse effect on stability. C_L, C_D, and C_m are tabulated for the range of test conditions.

Wind-Tunnel Tests on an Aircraft Designed for Super-Sonic Speeds. I High-Speed Wind-Tunnel Tests on a 1/6.15 Scale Model Aircraft. S. P. Hutton and H. E. Gamble. **II—No. 2 11½-Ft. Wind-Tunnel Tests on a ¼-Scale Model Wing.** I. Levačić, W. S. D. Marshall, and A. D. Young. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2404*, 1950 (July, 1945). 28 pp., illus. 9 references. British Information Services, New York. $1.25.

Tests run in R.A.E. wind tunnels: **I.** At $M = 0.30$-0.82, incidences from 0° to stall, $R = 0.8 \times 10^6$ to check aircraft stability at high speeds and the low-speed landing condition. **II.** Wing speeds of 80, 120, and 180 ft. per sec. and $R = 0.66 \times 10^6$ to $R = 1.5 \times 10^6$ for the wing without flaps, and at 80 and 120 ft. per sec. on a wing with part-span split flaps to check the scale effect on lift and drag.

Low Speed Tunnel Investigation of the Effect of the Body on C_{m_0} and Aerodynamic Centre of Unswept Wing-Body Combinations. A. Anscombe and D. J. Raney. *Gt. Brit., Aeronautical Research Council, Current Papers No. 16*, 1950 (April, 1949). 73 pp., illus. 16 references. British Information Services, New York. $1.25.

The changes in aerodynamic center and C_{m_0} due to body have been found for a range of body front and rear lengths, nose shape, body width and depth, wing-body angle and height, and wing aspect ratio in tests of a body on an unswept tapered wing. The change in aerodynamic center is affected chiefly by body front length and width; it is almost independent of body depth, wing-body angle, and wing height. C_{m_0} varies linearly with the angle between wing no-lift line and body axis; the effect of wing height is small. Tests on various root fillets indicated that fillets have a small effect on aerodynamic center, but a considerable effect on C_{m_0}.

The Dynamic Lateral Control Characteristics of Airplane Models Having Unswept Wings with Round- and Sharp-Leading-Edge Sections. James L. Hassell and Charles V. Bennett. *U.S., N.A.C.A., Technical Note No. 2219*, November, 1950. 26 pp., illus. 6 references.

An investigation in the Langley free-flight tunnel of a normal inertia model and a model with high inertia in yaw; each model was tested with a N.A.C.A. 0012 (round-leading-edge) and a 12 per cent thick biconvex (sharp-leading-edge) wing. The program consisted of static and rotary force tests and flight tests for the evaluation of the dynamic lateral control characteristics.

THERMOAERODYNAMICS

Heat Transfer to Bodies Traveling at High Speed in the Upper Atmosphere. Jackson R. Stalder and David Jukoff. *U.S., N.A.C.A., Report No. 944,* 1949. 13 pp., illus. 16 references. U.S. Govt. Printing Office, Washington. $0.15.

WINGS & AIRFOILS

Effect of Geometric Dihedral on Low-Speed Static Stability Characteristics of a 40° Swept-Back Wing. Kazimierz Orlik-Rückemann. *Sweden, Kungl. Tekniska Högskola, Institution for Flygteknik, Technical Note No. KTH—AERO TN 17,* 1950 (May 17, 1949). 17 pp., illus. 6 references. In English.

Six components and forces were measured at low speed on a wing with a taper ratio of 0.5 and an aspect ratio of 4.5. For small dihedral angles, the lift-curve slope varies approximately as $\cos^3$ of the geometric dihedral angle; geometric dihedral has only a slight effect on the static longitudinal-stability parameter of the wing.

The Calculation of Downwash Behind Supersonic Wings with an Application to Triangular Plan Forms. Harvard Lomax, Loma Sluder, and Max A. Heaslet. *U.S., N.A.C.A., Report No. 957,* 1950. 19 pp., illus. 10 references. U.S. Govt. Printing Office, Washington. $0.20.

An outline of the theoretical approach to the determination of the velocity potential in a flow field with a supersonic lifting surface; the calculation of the downwash using supersonic doublet distributions. The theory is applied to a thin triangular wing swept back of the Mach cone; complete calculations are given for the downwash over the chord plane in the extended wake of the wing and on the vertical plane of symmetry to 40 per cent of the semispan. The mathematical portion of the method can be applied to other plan forms.

The Yawed Delta Wing at Incidence at Supersonic Speeds. Gwendolen M. Roper. *Quarterly Journal of Mechanics and Applied Mathematics,* Vol. 2, Part 3, September, 1949, pp. 354–373, illus. 2 references.

The Flat Delta Wing at Incidence, at Supersonic Speeds, When the Leading Edges Lie Outside the Mach Cone of the Vertex. Gwendolen M. Roper. *Quarterly Journal of Mechanics and Applied Mathematics,* Vol. 1, Part 3, September, 1948, pp. 327–343, illus. 3 references.

Systematic Representation of Aerodynamic Coefficients of an Oscillating Aerofoil in Two-Dimensional Incompressible Flow. D. J. Hofsommer. *Netherlands, Nationaal Luchtvaartlaboratorium, Amsterdam, Report No. F.61,* March 4, 1950. 39 pp., illus. 9 references. In English.

A modified version of the method of the acceleration potential is proposed for evaluating the pressures, forces, and moments acting on an oscillating airfoil. The pressure differential at a point on the airfoil is obtained from this acceleration potential; the forces and moments on the airfoil and its control surfaces are obtained from the pressure difference. The resulting formulas are applicable to an airfoil with an arbitrary number of flaps. New approximations are given for the forces on a thin-airfoil control surface.

Measurement of the Derivative z_w for an Oscillating Aerofoil. A. L. Buchan, K. D. Harris, and P. M. Somervail. *College of Aeronautics, Cranfield, England, Report No. 40,* June, 1950. 33 pp., illus. 3 references. Measurements of the damping derivative z_w for constant-chord rigid wings of various aspect ratios with sweepback angles of 0° and 45°.

The Application of Green's Theorem to the Solution of Boundary-Value Problems in Linearized Supersonic Wing Theory. Max A. Heaslet and Harvard Lomax. *U.S., N.A.C.A., Report No. 961,* 1950. 14 pp., illus. 23 references. U.S. Govt. Printing Office, Washington. $0.15.

Wind-Tunnel Tests on an Aircraft Designed for Super-Sonic Speeds. I High-Speed Wind-Tunnel Tests on a 1/6.15 Scale Model Aircraft. S. P. Hutton and H. E. Gamble. **II—No. 2 11½-Ft. Wind-Tunnel Tests on a ¼-Scale Model Wing.** I. Levačić, W. S. D. Marshall, and A. D. Young. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2404,* 1950 (July, 1945). 28 pp., illus. 9 references. British Information Services, New York. $1.25.

Tests run in R.A.E. wind tunnels: **I.** At $M = 0.30$–0.82, incidences from 0° to stall, $R = 0.8 \times 10^6$ to check aircraft stability at high speeds and the low-speed landing condition. **II.** Wing speeds of 80, 120, and 180 ft. per sec. and $R = 0.66 \times 10^6$ to $R = 1.5 \times 10^6$ for the wing without flaps, and at 80 and 120 ft. per sec. on a wing with part-span split flaps to check the scale effect on lift and drag.

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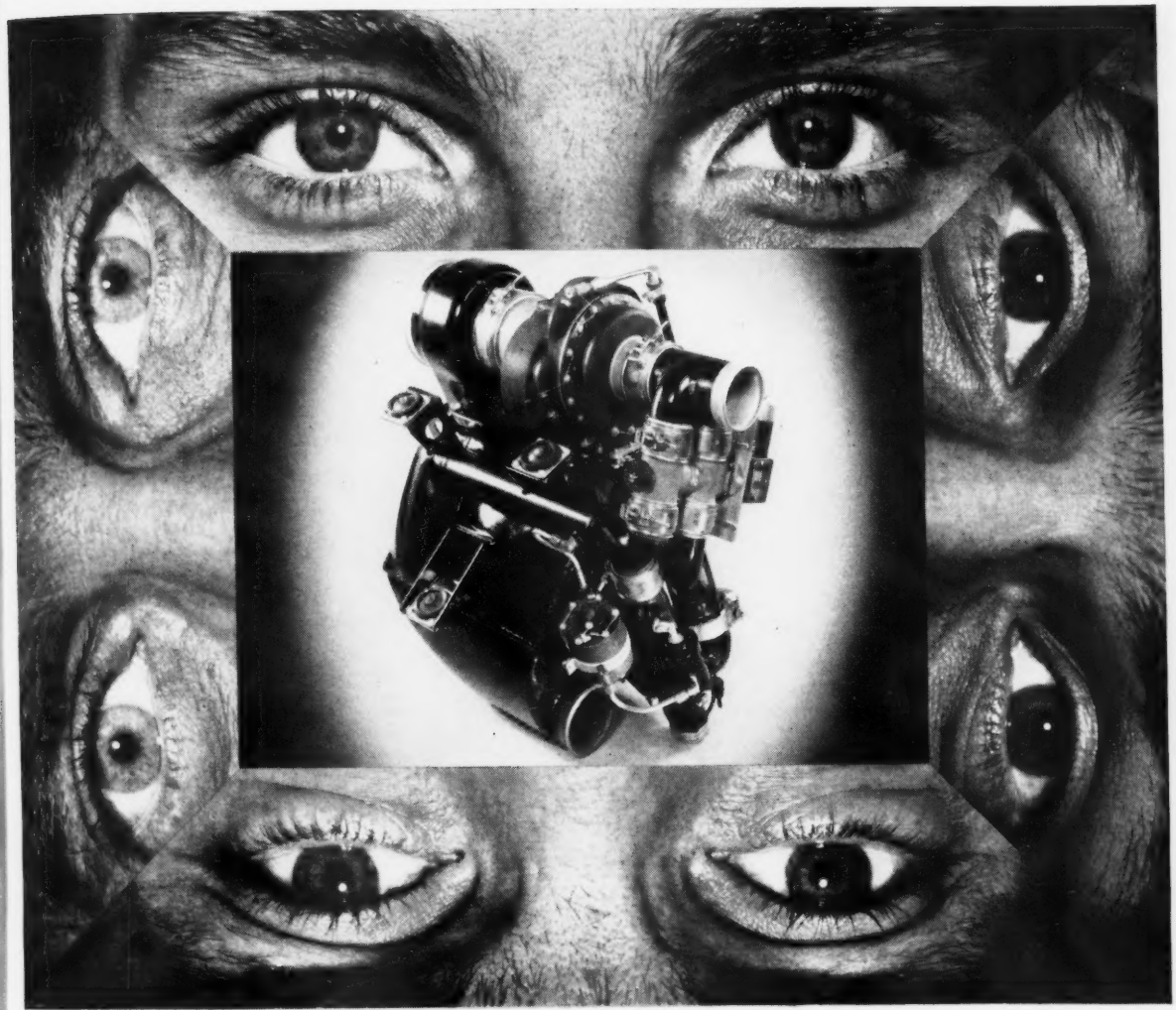

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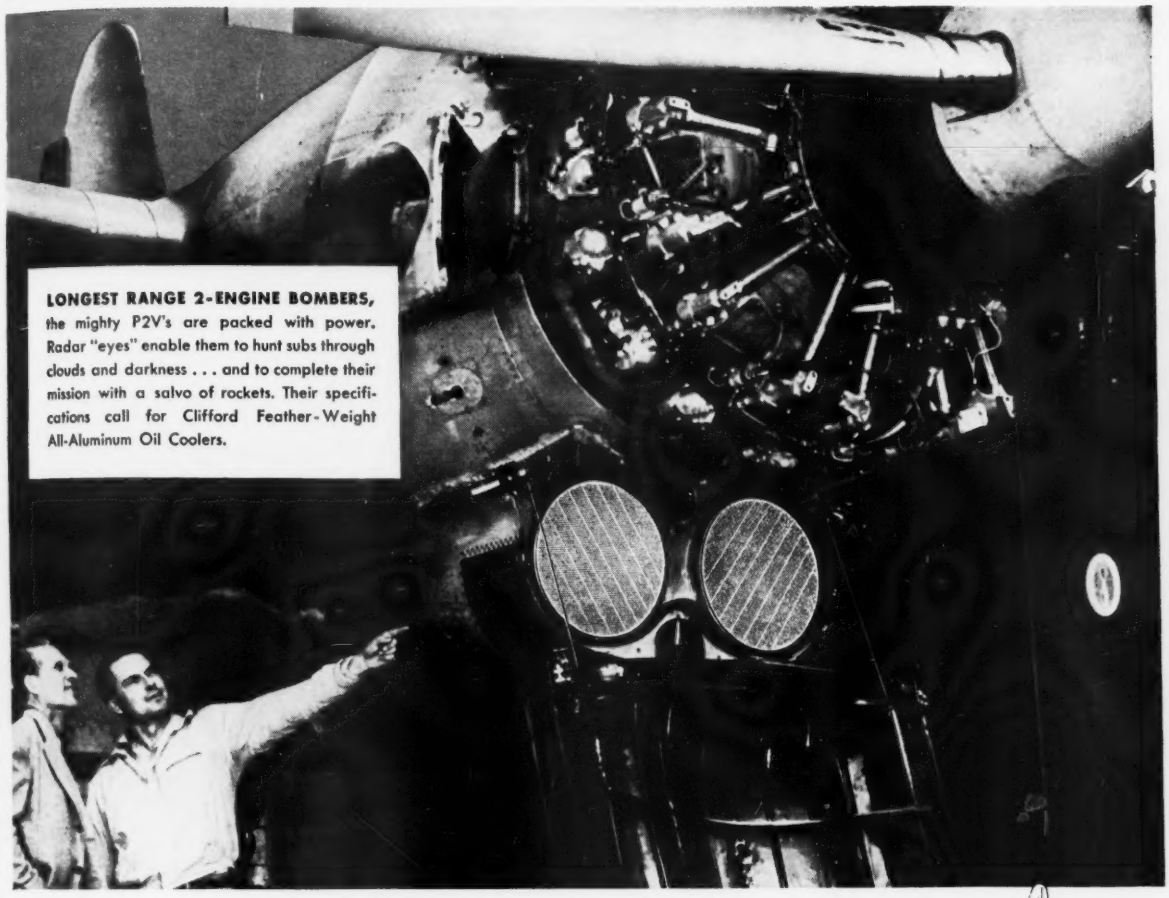

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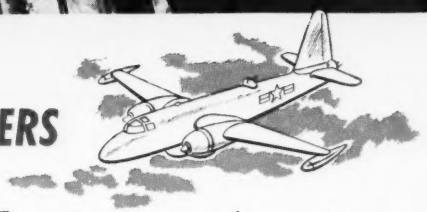

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Comparison of Tropospheric Reception; at 44.1 Mc. and at 92.1 Mc. over the 167 Mile Path, Alpine, New Jersey, to Needham, Massachusetts, 1947–1948. Greenleaf W. Pickard and Harlan T. Stetson. *Journal of Atmospheric and Terrestrial Physics*, Vol. 1, No. 1, 1950, pp. 32–36, illus. 2 references.

Solare und terrestrische Beobachtungen während des Mögel-Dellinger-Effektes (SID) am 19. November 1949. *Journal of Atmospheric and Terrestrial Physics*, Vol. 1, No. 1, 1950, pp. 37–48, illus. 18 references. In German. Solar and terrestrial observations during the sudden ionospheric disturbance of November 19, 1949.

27-Day Variations in F_2 Layer Critical Frequencies at Huancayo. Julius Bartels. *Journal of Atmospheric and Terrestrial Physics*, Vol. 1, No. 1, 1950, pp. 2–12, illus. 11 references.

Polarimeter for the Study of Low Frequency Radio Echoes. A. H. Benner and H. J. Nearhoof. *Review of Scientific Instruments*, Vol. 21, No. 10, October, 1950, pp. 830–834, illus. 6 references.

Equipment

ELECTRICAL (16)

Wide-Range-Speed A-C Electric System for Aircraft. H. B. James, R. P. Judkins, and C. L. Mershon. *Electrical Engineering*, Vol. 69, No. 12, December, 1950, p. 1101, illus.

Design of a 30-kva. 3-phase 0.9-power factor 208/120-volt 400/800-cycles per sec. 4,000/8,000-r.p.m. alternator and its exciter. This design uses a d.c. generator exciter built integrally into the alternator and controlled by a carbon-pile voltage regulator.

Some Problems in Aircraft Magneto Development. R. T. Coe and D. F. Welch. *Institution of Electrical Engineers, Proceedings, Part 2, Power Engineering*, Vol. 97, No. 58, August, 1950, pp. 485–500, Discussion, pp. 500–506, illus. 12 references. Review of present-day requirements, fundamentals of magneto operation, development of contact-breakers, and electrical limitations.

HYDRAULIC & PNEUMATIC (20)

Pneumatic Versus Hydraulic Systems for Aircraft. H. F. Gerwig and J. H. Famme. *Product Engineering*, Vol. 21, No. 11, November, 1950, pp. 91–95, illus., cutaway drawings. Actual performance comparison of the hydraulic and pneumatic systems of the Convair-Liner. Component weights for each system are tabulated.

The Closed Circuit Hydraulic System for Aircraft Applications. Carl L. Sadler. *Applied Hydraulics*, Vol. 3, No. 10, November, 1950, pp. 24–26, illus. 1 reference. Advantages and possible applications.

Wafer Licks Hydraulic Pulsation. George L. Christian. *Aviation Week*, Vol. 53, No. 22, November 27, 1950, pp. 31, 32, 34, illus.

A modification developed by Vickers, Inc. to avoid hydraulic pump pulsation. A metered-valve wafer is inserted between the pump housing and the valve plate; the wafer has a metering groove in one end of the pressure-port kidney.

Flight Operating Problems (31)

ICE PREVENTION & REMOVAL

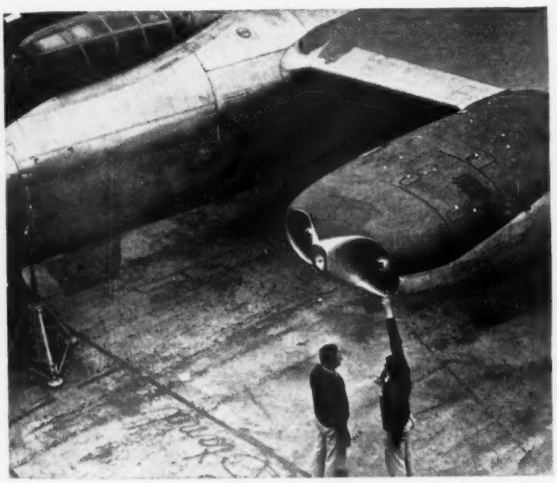
The Effect of Ice Formations on Propeller Performance. Carr B. Neel, Jr., and Loren G. Bright. *U.S., N.A.C.A., Technical Note No. 2212*, October, 1950. 96 pp., illus. 16 references.

In-flight measurements and theoretical analysis of propeller efficiency losses due to natural icing conditions. In general, the efficiency loss will be less than 10 per cent, although a maximum loss of 20 per cent may occur.

Flying Labs Check Icing Conditions; Create Ice on the Fuselage If Needed. *U.S., Central Air Documents Office (Army-Navy-Air Force), Technical Data Digest*, Vol. 15, No. 11, November, 1950, pp. 5, 6, illus.

Economical De-Icing; Results of a B.E.A. Investigation of the Porosint Fluid-Distributor. *Flight*, Vol. 58, No. 2183, November 23, 1950, p. 468, illus.

B.F.Goodrich



4 hot ideas for fighting ice

The pipe that flies like a plane. Boeing's new Flying Boom for in-flight refueling (upper left) is actually flown into place by means of vee-shaped ruddevators. To provide accurate control, these ruddevators had to be protected against ice. B. F. Goodrich developed special electric rubber pads for the leading edges that supply spot anti-icing heat.

Electric blankets keep new Arctic plane from freezing. Designed for Arctic rescue work, Northrop's new C-125 (upper right) had to have ice protection at all vital spots. BFG electric rubber "blankets" turned the trick for three parts—antenna mast, elevator horn and air scoops. Because of the design flexibility of electric rubber, wide variation in the shape of these three parts proved no obstacle.

Keeps ice from choking jet's throat. Ice forming in the narrow "throat" of a jet engine intake could choke off the air supply, make the engine quit cold. This threat has been eliminated on North American's B-45 (lower left) with a special lining of BFG electric rubber inside the cowl.

Rubber makes gasoline stretch. To help flight engineers adjust fuel supply for maximum efficiency, a hydraulic line transmits propeller load to an instrument panel dial. But cold was congealing the oil, causing false readings. BFG engineers sheathed the hydraulic line in electric rubber to keep the oil fluid, save gasoline. This heated line is now standard on TWA Constellations (lower right).

B. F. Goodrich electric rubber is tough, thin rubber with a core of resistance wires that provide spot heat precisely as needed. Two lead wires attached to the airplane's regular power supply are the only other equipment required. Electric rubber can be made to fit any size, any shape airplane part. For help with your problems write to *The B. F. Goodrich Company, Aeronautical Division, Akron, Ohio.*

B.F.Goodrich
FIRST IN RUBBER

NOISE REDUCTION

A Comparative Study of the Noise from Turbo-Jet and Reciprocating Aircraft Engines in Flight. S. C. Ghose. *Royal Aeronautical Society, Journal*, Vol. 54, No. 479, November, 1950, pp. 697–707, illus. 9 references.

The noise spectrum of reciprocating and turbojet engines was experimentally analyzed in an Avro Lancaster "flying test bed" equipped with two Rolls-Royce Merlin reciprocating engines and two de Havilland Ghost turbojets. The test equipment consisted of a narrow-band low-frequency analyzing apparatus and a constant-bandwidth heterodyne analyzer with two types of high-frequency microphones. The noise spectra from the two engine types are compared in the forward and rear portions of the fuselage.

REFUELING IN FLIGHT

Flight Refueling. W. S. Friedman. *The Pegasus*, Vol. 16, No. 5, November, 1950, pp. 12–15, illus. The development of flight refueling techniques in the U.S. and Great Britain.

Hydraulically Operated Pump to Speed Mid-Air Plane Refueling. *U.S., Central Air Documents Office (Army-Navy-Air Force), Technical Data Digest*, Vol. 15, No. 12, December, 1950, p. 9, illus.

WEATHER HAZARDS

Lightning and the Airplane. Merrill Jones. *Flight Lines*, Vol. 1, No. 2, November, 1950, pp. 14–17, illus. Research on lightning strikes, their effects, and preventive measures at the Lightning and Transients Research Institute, Inc., Minneapolis.

Flight Safety & Rescue (15)

Hazards Involved in the Use of Rocket Propellants. Marc P. Dunnam. *U.S., Central Air Documents Office (Army-Navy-Air Force), Technical Data Digest*, Vol. 15, No. 11, November, 1950, pp. 30–32.

Physical dangers to personnel in handling and using red and white fuming nitric acid, aniline, xylidine, and furfuryl alcohol; methods of fire prevention and of extinguishing fires resulting from improper handling of these chemicals.

Determination of Means to Safeguard Aircraft from Power Plant Fires in Flight. IV—The Boeing B-29. Lyle E. Tarbell and H. R. Keeler. *U.S., Civil Aeronautics Administration, Technical Development Report No. 107*, April, 1950 (October, 1949). 36 pp., illus. 8 references.

Investigation of causes of power-plant fire in flight. The chief source of trouble was the exhaust system, principally the region surrounding the superchargers and the exhaust stacks. Tests indicated that overheated motors did not appear to be ignition sources, but blocked vacuum systems could be a definite hazard. Gasoline, S.A.E. 10 oil, and a few low-volatility fuels were sprayed on ignition sources to determine their comparative flammability. Two fire detectors were tested. Suggestions for power-plant fire prevention based upon the test results are made.

How Airport Fires Can Be Prevented. Barbara J. Ward. *American Aviation*, Vol. 14, No. 19, November 27, 1950, pp. 45, 47, 48, illus. Brief summaries of destruction caused by fire and suggestions for preventing these types of fires.

Present-Day Stalling Risks with Civil Aircraft. K. W. Clark. *Aircraft Engineering*, Vol. 22, No. 261, November, 1950, pp. 338, 339.

Flight Testing (13)

Remote Control for Safer Test Flying. George L. Christian. *Aviation Week*, Vol. 53, No. 21, November 20, 1950, pp. 44, 47–49, illus. Brief review of research on remote control of aircraft; details of the video-monitored radio control system developed by the A.M.C. and Lear, Inc.

Measurement of Aircraft Height and Speed in High Speed Dives by a Photographic Method and by Radar Tracking. D. W. Lang. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2351*, 1950 (January, 1946). 16 pp., illus. 4 references. British Information Services, New York. $0.75.

Height is measured by photographing the ground with a camera in the aircraft and comparing the photograph with a map of the same area. The accuracy is poor; the average error is about ±5 per cent in altitude. Tracking the aircraft with an SCR-584 radar measures speed and height; Mach Number can be determined to within 1½ per cent; altitude to within 400 ft. Both methods are compared with auto-observer results.

The Investigation of Air Loads in Flight from Measurements of Strain in the Structure. J. Taylor. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2408*, 1950 (November, 1945). 4 pp., illus. 2 references. British Information Services, New York. $0.30.

For most in-flight measurements, the overall bending and shear actions are required for approximately five stations on each major component. Four to eight measurements at each station should be sufficient if the proper gage positions are used.

The Determination of Propeller Efficiency in Flight; Preliminary Tests with a Rotol Propeller. K. Eyre. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2414*, 1950 (July, 1946). 10 pp., illus. 5 references. British Information Services, New York. $0.65.

Thrust was measured by the wake-traverse method; torque from observed engine conditions and test-bench calibrations. Test flights were made in a Spitfire IX fitted with a standard Rotol propeller and Merlin 70 engine at a forward speed of 382 m.p.h., engine speed of 3,000 r.p.m. (tip Mach Number = 0.98), and four different values of engine power. This technique of flight testing shows that propeller efficiency can be measured to ±5 per cent, at a forward speed of 600 m.p.h. at 25,000 ft.

Fuels & Lubricants (12)

Hazards Involved in the Use of Rocket Propellants. Marc P. Dunnam. *U.S., Central Air Documents Office (Army-Navy-Air Force), Technical Data Digest*, Vol. 15, No. 11, November, 1950, pp. 30–32.

Physical dangers to personnel in handling and using red and white fuming nitric acid, aniline, xylidine, and furfuryl alcohol; methods of fire prevention and of extinguishing fires resulting from improper handling of these chemicals.

The Rate of Evaporation of a Kerosine Spray. W. Sacks. *Canada, National Research Council, National Research Laboratories, Division of Mechanical Engineering, Report No. MF-2816*, July 20, 1950. 19 pp., illus. 8 references.

Measurement of the evaporation of a kerosene spray at 22°C by the gravimetric analysis of an air stream passing through the spray developed by a miniature pressure-jet atomizer at 50 and 80 lbs. per sq.in. fuel pressure. The rate of evaporation was found to be approximately 0.3 per cent per sec. at room temperature. Calculations were made of the evaporation rate for the same conditions; evaporation constants were obtained from the Langmuir equation for the evaporation of a droplet. Use of this expression does not yield accurate values when applied to a spray because of mutual interference of the droplets.

Catalytic Isomerization of 1-Hexane. E. A. Naragon. *Industrial and Engineering Chemistry*, Vol. 42, No. 12, December, 1950, pp. 2490–2493, illus. 10 references.

Mode of Action of Phenothiazine-Type Antioxidants. C. M. Murphy, Harold Ravner, and Nathan L. Smith. *Industrial and Engineering Chemistry*, Vol. 42, No. 12, December, 1950, pp. 2479–2489, illus. 16 references.

Determination of Aromatics and Olefins in Wide Boiling Petroleum Fractions. A. E. Spakowski, Albert Evans, and R. R. Hibbard. *Analytical Chemistry*, Vol. 22, No. 11, November, 1950, pp. 1419–1422, illus. 15 references.

Symposium: Synthetic Lubricating Oils, American Chemical Society, 117th Meeting, March, 1950, Houston, Texas. *Industrial and Engineering Chemistry*, Vol. 42, No. 12, December, 1950, pp. 2414–2468, illus. 220 references.

Contents: Structural Guides for Synthetic Lubricant Development, C. M. Murphy and W. A. Zisman. Functional Selection of Synthetic Lubricants, R. G. Larsen and A. Bondi. Review of German Synthetic Lubricants, William A. Horne. Polyalkylene Glycol Synthetic Lubricants, W. H. Millett. Polymeric Additives for Synthetic Ester Lubricants, F. J. Glavis. Noncatalytic Polymerization of Olefins to Lubricating Oils, F. M. Segar, H. G. Doherty, and A. N. Sachanen. Boundary Lubricating Characteristics of Organopolysiloxanes, C. C. Currie and M. C. Hommel. Flow Characteristics of Organopolysiloxane Fluids and Greases, C. C. Currie and B. F. Smith. Thermal and Oxidation Stability

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of Polymethylphenylsiloxanes, C. M. Murphy, C. E. Saunder and D. C. Smith.

Lubricants Produced by Reactions in Glow Discharge. R. S. Whiteley, C. N. Kimberlin, G. L. Matheson, and R. W. Richardson. *Industrial and Engineering Chemistry*, Vol. 42, No. 12, December, 1950, pp. 2471–2479, illus. 25 references.

Guided Missiles (1)

Aerodynamic Interference in Supersonic Missiles. P. A. Lagerstrom and M. E. Graham. *Douglas Aircraft Company, Inc., Report No. SM-13743*, July, 1950. 82 pp., illus. 19 references.

Investigation of vortex-interference on a missile with low-aspect-ratio lifting surfaces and a small-wing-span-fuselage-ratio diameter. Wing-fuselage interference and wing-fuselage-tail interference are studied. In the examination of wing-fuselage interference, slender-body theory is used, and corrections are applied to it from an estimation of planar systems that have exact linearized solutions and from a general consideration of low-aspect-ratio theory. For the problem of wing-fuselage-tail interference, the spanwise lift on the wing is calculated. A "rolled-up" vortex sheet is assumed. The vortex sheet is replaced by two vortex lines, and the downwash calculated from the positions and flow, field of the vortices.

Chemical Analysis of Atmosphere Samples from 50 and 70 Km Height. K. F. Chackett, F. A. Paneth, and E. J. Wilson. *Journal of Atmospheric and Terrestrial Physics*, Vol. 1, No. 1, 1950, pp. 49–55, illus. 10 references. Analysis of air samples collected in the U.S. by means of V-2 rockets fitted with a mechanism to take samples of air during free climb.

Tactical Use of Guided Missiles; Their Potentialities in Support of Ground Combat. N. M. Bengtson. *Ordnance*, Vol. 35, No. 183, November-December, 1950, pp. 184–186, illus.

Instruments (9)

Flight Control Unit. Michael A. Argentieri. *Machine Design*, Vol. 22, No. 11, November, 1950, pp. 143–145, illus.

Design features and principles of operation of the Kollsman automatic altitude control. Used with an automatic pilot, this control utilizes an aneroid-actuated mechanism coupled with an inductive pickoff through a direct-current magnetic clutch. It maintains the aircraft at a fixed barometric altitude by overriding the gyros of the autopilot.

Instrumentation Report for Automatic Control for the Measurement of Stability and Control Characteristics of the B-25J. I—Longitudinal Phase. II—Lateral Phase. Maurice Walter. *Cornell Aeronautical Laboratory, Inc., Report No. TB-405-F-8*, September 15, 1947. 203 pp., illus. 10 references.

A Design Method for Automatic Longitudinal Control Systems. Frederick Stevens and K. Martin Stevenson. *Aeronautical Engineering Review*, Vol. 10, No. 1, January, 1951, pp. 18–23, illus. 1 reference.

Readers' Forum: Note on "Longitudinal Stability of Autopilot-Controlled Aircraft." G. J. Sissingh. *Journal of the Aeronautical Sciences*, Vol. 18, No. 1, January, 1951, p. 65.

Importance of Extending Nyquist Servomechanism Analysis to Include Transient Response. R. L. Johnson and J. B. Rea. *Journal of the Aeronautical Sciences*, Vol. 18, No. 1, January, 1951, pp. 43–49, illus. 14 references.

The importance of extending the Nyquist servomechanism analysis to include the transient response is stressed. The transient response is obtained from the frequency response by the Fourier method.

Carrier-Controlled Relay Servos. J. C. Lozier. *Electrical Engineering*, Vol. 69, No. 12, December, 1950, pp. 1052–1056, illus. 4 references.

What Size Motor for Proper Operation of Servomechanism? George C. Newton, Jr. *Machine Design*, Vol. 22, No. 11, November, 1950, pp. 125–130, 200, 202, illus. 10 references.

Relay Servomechanisms; The Shunt-Motor Servo with Inertia Load. T. A. Rogers and W. C. Hurty. *American Society of Mechanical Engineers, Transactions*, Vol. 72, No. 8, November, 1950, pp. 1163–1172, illus. 6 references.

Carrier Compensation for Servomechanisms. I. H. Elmore Blanton. *Franklin Institute, Journal*, Vol. 250, No. 5, November, 1950, pp. 391–407, illus.

A New Approach to the Design of Pulse-Monitored Servo Systems. A. Porter and F. W. Stoneman. **Appendix.** D. F. Lawden. *Institution of Electrical Engineers, Proceedings, Part 2, Power Engineering*, Vol. 97, No. 59, October, 1950, pp. 597–611, illus. 8 references.

Nonlinear Techniques for Improving Servo Performance. Donald McDonald. *Cook Research Laboratories, Bulletin No. S-2*, September 27, 1950. 33 pp., illus. 1 reference.

Methods of improving the ability of a servo or automatic to follow rapidly varying motion. A graphic procedure is used for analyzing the high-speed operation of the servo. Phase plane and space analysis are applied to nonlinear servo problems to explain analytically the effect of nonlinear elements in the mechanism and to provide aids for the design of nonlinear servos.

The Measurement of Angle of Attack and Angle of Yaw in Flight. D. W. Young. *U.S., Central Air Documents Office (Army-Navy-Air Force), Technical Data Digest*, Vol. 15, No. 11, November, 1950, pp. 23–30, illus.

The null-pressure-type indicator measures both angle of attack and angle of yaw to an accuracy of $^1/_{10}$ of one degree. The instrument, suitable for flight testing, keeps the aircraft at the optimum lift-drag ratio.

A New Compensated-Float Method of Liquid-Level Gaging for Aircraft. R. G. Ballard. *Instruments*, Vol. 23, No. 10, October, 1950, pp. 1006, 1007, illus. 2 references.

A method of float compensation which can be adapted to existing installations and has the advantages of simplicity, maintenance ease, light weight, and low initial cost. The float is fastened rigidly to the transmitter float arm so that the float rests on its side when the tank is empty, moves through an angle of 90° as the tank is filled, and becomes upright to provide maximum compensation at full tank. However, the moving parts in the tank may be a disadvantage in aircraft applications.

Analogue Methods for Turbojet Thrust Instrumentation. E. S. Van Valkenburg and N. W. Matthews. *Electrical Engineering*, Vol. 69, No. 11, November, 1950, p. 1004, illus. (Digest of a paper.)

Response Characteristics of Temperature-Sensing Elements for Use in the Control of Jet Engines. Andrew I. Dahl and Ernest F. Fiock. *U.S., National Bureau of Standards, Journal of Research*, Vol. 45, No. 4, October, 1950, pp. 292–298, illus. 7 references. (Also available as *Research Paper No. RP2136*. U.S. Govt. Printing Office, Washington. $0.10.)

Investigation of the rate of response (characteristic time) in the control of turbine-type engines, where the temperature-sensing element is immersed in the gas stream. The characteristic time depends chiefly on the mass-flow rate and is practically independent of temperature level, temperature difference, and direction of the net heat flow. Convection is the controlling factor in heat transfer in the turbine engine. The factors that determine the rate of response are considered, and their relative importance is compared. The test apparatus is described. Results show that the rate of response varies greatly with flight altitude and engine speed.

Apparatus Checks Jet Thermometer. *Aviation Week*, Vol. 53, No. 22, November 27, 1950, pp. 24, 25, 27, illus. An apparatus designed by the National Bureau of Standards to measure response rates of temperature sensing elements in jet-engine exhaust streams.

The Development of the Aircraft Automatic Radio Compass. J. H. Moon. *Institute of Navigation, Journal*, Vol. 3, No. 4, October, 1950, pp. 393–403, illus. 6 references.

The Pfund Sky Compass. Alton B. Moody. *Navigation*, Vol. 2, No. 7, September, 1950, pp. 234–239.

The Air Accuracy of Compasses. J. L. Nunn. *Institute of Navigation, Journal*, Vol. 3, No. 4, October, 1950, pp. 404–411, illus. 1 reference.

Periscopic Sextant Eliminates Drag-Inducing Astrodomes. *U.S., Central Air Documents Office (Army-Navy-Air Force), Technical Data Digest*, Vol. 15, No. 12, December, 1950, pp. 5, 6, illus.

Hermetic Sealing of Aircraft Instruments. R. F. Buckley. *General Electric Review*, Vol. 53, No. 11, November, 1950, pp. 43–45, illus. 5 references. Advantages of hermetically sealing aircraft instruments; the sealing process; and testing the assembled instrument.

Edge Lighting Gives Dial Clarity. *Aviation Week*, Vol. 53, No. 22, November 27, 1950, p. 22, illus. Hawker Aircraft, Ltd.

Allison Powers FIRST FLIGHT of First Turbo-Prop Transport

THE first U.S. turbine transport is now a reality and is under test. It was made possible through the private enterprise and initiative of the Allison Division of General Motors. First flight was completed December 29, 1950 with an Allison-owned Convair Turbo-Liner equipped with two Allison "501" Turbo-Prop engines.

This investment in the future of Turbo-Prop power is the result of Allison determination to speed the development of turbine transports in this country. The Allison "501" Turbo-Prop engines, developed under sponsorship of the U.S. Navy, are the most advanced Turbo-Prop engines in the U.S. today. They lead the world in high power for their low weight. They will make possible smoother, more economical transports to carry increased loads of passengers and freight.

Allison will prove these advantages in an extended flight test program on the Turbo-Liner. The results —to be made available to the military services, aircraft manufacturers and commercial air lines—will prove the safe and dependable operation of Turbo-Prop power.

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development for constant-level illumination of photopanels uses four lights per instrument dial face.

Measurement of the Internal Diameters of Metallic Capillary Tubes. Charles T. Collett, John C. Hughes, and Francis C. Morey. *U.S., National Bureau of Standards, Journal of Research*, Vol. 45, No. 4, October, 1950, pp. 283–288, illus. 1 reference. (Also available as *Research Paper No. RP2134*. U.S. Govt. Printing Office, Washington. $0.10.) Experimental technique.

Shop Facilities for Testing Pressure Instruments. I. W. D. Wood. *Taylor Technology*, Vol. 3, No. 2, Autumn, 1950, pp. 24, 25, illus.

Attenuation of Oscillatory Pressures in Instrument Lines. Arthur S. Iberall. *U.S., National Bureau of Standards, Journal of Research*, Vol. 45, No. 1, July, 1950, pp. 85–108, illus. (Also available as *Research Paper No. RP2115*. U.S. Govt. Printing Office, Washington. $0.15.)

A relatively simple treatment for the transmission of oscillatory pressures in tubing. An elementary solution is developed on the basis of incompressible, viscous-fluid flow theory; this solution is extended to include compressibility effects, finite pressure amplitudes, appreciable frequencies of oscillation, and tubing length. The effect of heat transfer in modifying the oscillatory response of the tube is also examined. The elementary theory of transmission lags is developed. The complete theory, with corrections, is presented in graphic form suitable for computing the lag and attenuation of a sinusoidal oscillation in a transmission tube. The mathematical derivation of more exact solutions is given.

A Simple Manometer for Use in Measuring Low Air Velocities. D. B. Spalding. *Journal of Scientific Instruments*, Vol. 27, No. 11, November, 1950, pp. 310–312, illus. 2 references.

Two designs of a simple direct-reading instrument are described for measuring steady differential air pressure down to 0.002 mm. of water column. The differences of liquid level are magnified by the tilting of a mirror supported on floats.

The Three-Quarter Radius Pitot Tube Flow Meter. J. H. Preston. *The Engineer*, Vol. 190, No. 4944, October 27, 1950, pp. 400–402, illus. 3 references.

The flow meter uses a number of equally spaced pitot tubes at $^3/_4$ radius in a circular pipe. This instrument is compact, has a low loss, and asymmetry can be detected by examining the reading of the individual tubes. The theory and operation of the instrument are presented, along with experimental results with a meter of this type.

Response of Accelerometers to Transient Accelerations. Samuel Levy and Wilhelmina D. Kroll. *U.S., National Bureau of Standards, Journal of Research*, Vol. 45, No. 4, October, 1950, pp. 303–309, illus. 5 references. (Also available as *Research Paper No. RP2138*. U.S. Govt. Printing Office, Washington. $0.10.)

Curves and tables for three types of acceleration-time relations; outline of the theory of a single-degree-of-freedom mechanical system. The accelerometers for which the response was computed had natural periods of 1, $^1/_3$, and $^1/_2$ the duration of the acceleration pulse.

More Accuracy for V-G Recorder. *Aviation Week*, Vol. 53, No. 20, November 13, 1950, p. 32, illus.

The N.A.C.A. velocity-gravity recorder has an oil-damped acceleration mechanism instead of a friction-damping device. The oil-damped unit requires no adjustment, is more accurate, eliminates resonance at vibration frequencies, and shows no evidence of rectification under sinusoidal acceleration outputs. Range of the acceleration linkage is -3 to $+6$ g-units; range of the air-speed linkage is 0–200 m.p.h.

Some Electrical Methods of Measuring Mechanical Quantities. F. J. Woodcock. *Institution of Electrical Engineers, Proceedings, Part 1, General*, Vol. 97, No. 106, July, 1950, pp. 136–148, Discussion, pp. 149–154, illus. 87 references.

Review of the methods of measuring electrical quantities in which the initial mechanical-electrical transduction changes a resistance, capacitance, or inductance, or generates an e.m.f. The basic mechanical and operating principles are discussed. Typical examples are classified according to the electrical principles involved.

A Stroboscope for the Illumination of Vibrating Wings. H. M Nelson and B. K. Barnett. *Australia, Department of Supply and Development, Aeronautical Research Laboratories, Instrument Note No. 49*, July, 1950. 12 pp., illus. 2 references. Design, performance, and operation of a stroboscope that consists of a pulse modulator driving a 100-watt fluorescent tube; the frequency range is 4–50 cycles per sec.

Photographic Methods for Producing Reticles. Carl Leistner. *Photographic Engineering*, Vol. 1, No. 1, January, 1950, pp. 7–15, illus. 8 references.

Lighter-Than-Air (40)

A British Airship Again. *Flight*, Vol. 58, No. 2182, November 16, 1950, pp. 418–420, illus.

Details of the Bournemouth, a 45,000-cu.ft. nonrigid airship now under construction. The airship will be 108 ft. in length and 27 ft. in diameter, will be powered by a 75-h.p. Salmson engine, will have a speed of 35–40 knots, and will carry four persons. The dirigible will be filled with hydrogen.

N-Type Airship (Goodyear) for Antisub Warfare Nearing Completion. *U.S., Central Air Documents Office (Army-Navy-Air Force), Technical Data Digest*, Vol. 15, No. 11, November, 1950, p. 9, illus.

Machine Elements (14)

Selection Factors for Mechanical Buffers. Joseph Brown. *Product Engineering*, Vol. 21, No. 11, November, 1950, pp. 156–160, illus. Design and operation of hydraulic, pneumatic, or mechanical brakes, shock absorbers, and dash pots.

Why Machine Parts Fail. VII—Failures Originating on the Drawing Board. Charles Lipton. *Machine Design*, Vol. 22, No. 11, November, 1950, pp. 158–162, illus. 7 references.

Approximately 20 per cent of all fatigue failures can be traced to faulty design. Improved design will reduce fatigue failures of keyways, splines, fillets, oil holes, threads, and gear teeth.

BEARINGS

Investigation of 75-Millimeter-Bore Cylindrical Roller Bearings at High Speeds. II—Lubrication Studies; Effect of Oil-Inlet Location, Angle, and Velocity for Single-Jet Lubrication. E. Fred Macks and Zolton N. Nemeth. *U.S., N.A.C.A., Technical Note No. 2216*, November, 1950. 38 pp., illus. 5 references.

SHAFTS & ROTATING DISCS

On the Torsion of a Shaft with Keyways. H. Okubo. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 3, Part 2, June, 1950, pp. 162–172, illus. 7 references.

Numerical investigation of the problem of a circular cylinder with one notch, using the relations between the maximum stress and the radius of curvature at the bottom of the notch and of stresses at fillets.

The Stresses in an Artillery Wheel. A. J. S. Pippard and J. E. Duncan. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 2, Part 4, December, 1949, pp. 398–411, illus. 3 references.

The spokes are replaced by an idealized disc that applies bending moments, radial forces, and tangential forces on the rim, but not radial shearing or circumferential stresses. The analysis leads to explicit solutions of the radial and tangential displacements of the rim and to the intensities of all actions between the disc and the rim. The actions for each spoke can be obtained by integrating the intensities.

TRANSMISSIONS, CLUTCHES, & DRIVES

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Maintenance (25)

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Boeing Service Guide, Issue No. 37, October, 1950. 8 pp., illus. Model 377 Stratocruiser.

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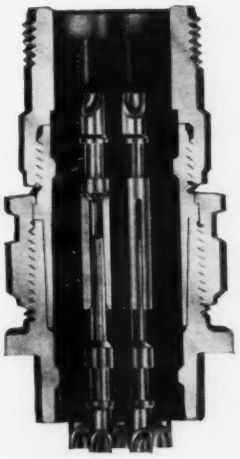

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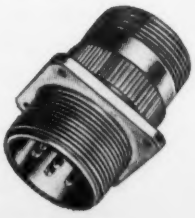

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The Aviation Subcontractor; Planning and Controlling a New Order. William Schweizer. *Aero Digest*, Vol. 61, No. 5, November, 1950, pp. 37, 58, 60.

Materials (8)

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A Variational Principle of Maximum Plastic Work in Classical Plasticity. R. Hill. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 1, Part 1, March, 1948, pp. 18–28, illus. 20 references.

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Test projects, equipment, and methods of investigating under natural conditions the corrosion of metals by sea water and marine atmosphere in the laboratory of International Nickel Company, Inc., at Kure Beach and Wrightsville Beach, N.C.

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The commonly accepted strength theories for explaining fractures in structural materials are obtained from static test data. These theories often give misleading results. The weaknesses of the theories are explained, and corrections in concepts and procedures are suggested.

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Experimental investigation of the extent of area where the mean value of the stress is taken in a mild steel by a torsion fatigue test; the testing apparatus is of the mechanical type. Test results are tabulated. Comparison with results of tension-compression tests indicates that the extent of area is chiefly dependent on the material and independent of experimental techniques.

Progress in Ultrasonic Methods of Materials Testing. O. Rüdiger. (*Stahl und Eisen*, Vol. 70, No. 13, June, 1950, pp. 561–565.) *The Engineers' Digest*, Vol. 11, No. 10, October, 1950, pp. 352–354, illus. 21 references. Principles, development, and applications of intensity, image-formation, echo, and resonance methods.

USAF Testing Titanium as Structural Material for Planes. *U.S., Central Air Documents Office (Army-Navy-Air Force), Technical Data Digest*, Vol. 15, No. 11, November, 1950, pp. 6, 7.

The research program on titanium structures includes a study of how to improve titanium production processes, the development of better alloys, the design of a complete titanium wing for a supersonic missile, and the design and fabrication of a complete aft fuselage section for a jet fighter. The fuselage section will include titanium forgings and rivets as well as sheet material. Titanium and its alloys are compared with aluminum and magnesium alloys and steel.

Diffusion of Chromium in α Cobalt-Chromium Solid Solutions. John W. Weeton. *U.S., N.A.C.A., Technical Note No. 2218*, November, 1950. 42 pp., illus. 11 references.

Fast Way to Build Fast Fighters!

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The diffusion of chromium was tested in a range of 0–40 atomic per cent chromium at temperatures of 1,360°, 1,300°, 1,150°, and 1,000°. Test apparatus is described, and results are plotted.

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Small Bending and Stretching of Sandwich-Type Shells. Eric Reissner. *U.S., N.A.C.A., Report No. 975*, 1950. 26 pp., illus. 10 references. U.S. Govt. Printing Office, Washington. $0.25. Derivation of a system of basic equations for analyzing small-deflection problems of sandwich-type shells.

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Investigation of the stratification of plane laminar flow by the method of small oscillations. Stratification of the densities is assumed in the boundary layer, but a constant density is assumed outside of the boundary layer. The effects of friction and profile curvature are included in the calculation. Experimental results agree well with the calculated values.

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Course Line Computer, New Navigational Aid. *Aero Digest*, Vol. 61, No. 5, November, 1950, pp. 70, 79, 80, 82, 83, illus.

The course-line computer automatically calculates a flight path; it is used in conjunction with VOR and DME equipment. The computer takes the bearing reading from the VOR and the distance information from the DME in the aircraft and calculates instantly and continuously the position of the aircraft in terms of the on-course, left or right of the desired course, and the distance along the course. An indicator panel is mounted in the cockpit. The original equipment was developed by the C.A.A.

World-Wide Coverage Radio Navigation for Aviation and Marine Services Using Land Based Facilities in the I.T.U. (100 KC-S) Band. Vernon I. Weihe. *Navigation*, Vol. 2, No. 7, September, 1950, pp. 200, 201.

Some Practical Wrinkles in Flying the RTCA Polar Coordinate System of Radio Navigation. Wilson P. Cogswell. *Navigation*, Vol. 2, No. 7, September, 1950, pp. 239–243.

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Ordnance & Armament (22)

Tests at Guidonia Model Basin on Electrically Propelled Aerial Torpedo F.F.F. 120–500–360. Cesare Cremona. (*Italy, Ministery dell'Aeronautica, Report No. 236*, April 5, 1943.) *U.S., Navo*

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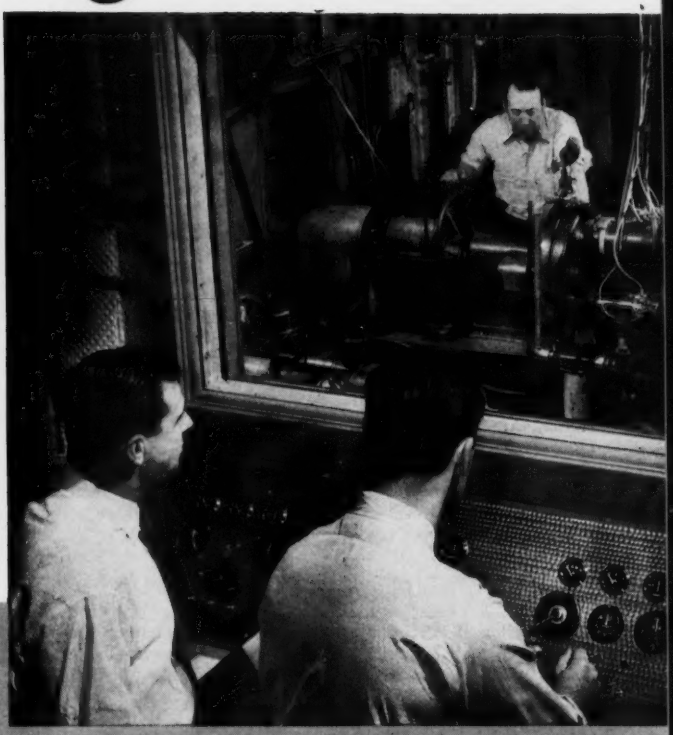

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Department, David W. Taylor Model Basin, Translation No. 196, September, 1950. 11 pp., illus.

Fighter Armament. IV—Ammunition and Elementary Ballistics; Vulnerability of Structures. A. R. Weyl. *Flight*, Vol. 58, No. 2183, November 23, 1950, pp. 459–461, illus.

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Porous Properties of Various Materials Liable to Be Used for Making Parachutes. W. D. Brown and J. F. Holford. *Gt. Brit., Aeronautical Research Council, Current Papers No. 24*, 1950 (March, 1949). 21 pp., illus. 2 references. British Information Services, New York. $0.50.

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Calibration of Precision Airplane Mapping Cameras. Francis E. Washer and Frank A. Case. *U.S., National Bureau of Standards, Journal of Research*, Vol. 45, No. 1, July, 1950, pp. 1–16, illus. 11 references. (Also available as *Research Paper No. RP2108*. U.S. Govt. Printing Office, Washington. $0.10.)

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Preliminary Report on High Altitude Photography. Clyde T. Holliday. *Photographic Engineering*, Vol. 1, No. 1, January, 1950, pp. 16–26, illus.

Instrumentation, film, and camera recovery after rocket landing; photographic techniques, quality of results, and summary of tests with camera installed in V-2 and Aerobee rockets.

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Power Plants

JET & TURBINE (5)

Revised and Extended Performance Characteristics of Ram Jets. D. F. Collins and Francis M. Gordon. *Gt. Brit., Aeronautical Research Council, Current Papers No. 11*, 1950. 42 pp., illus. 3 references. British Information Services, New York. $0.75.

Design point performance estimates of a ram-jet having a unit combustion-chamber cross-sectional area; a revised and extended analysis of previous calculations. Results are plotted vs. Mach Number at entry to the combustion chamber. Flight Mach Numbers covered are from 1.0 to 3.0 and maximum cycle temperatures are from 1,250° to 3,000°K. The performance of ram-jets with oblique and normal shock intakes are compared at a maximum cycle temperature of 2,000°K.; at $M = 3.0$, a complex intake of the oblique type is much better than the intake of the normal shock type.

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Development of theory, its application to the performance of an ideal and practical ram-jet. Calculations are carried out for Mach Numbers up to 3 and with the ratio of combustion temperature to atmospheric temperature up to 8.

Penetration of Liquid Jets into a High-Velocity Air Stream. Louis J. Chelko. *U.S., N.A.C.A., Research Memorandum No. E50F21*, August, 14, 1950. 23 pp., illus. 2 references.

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Effect of Compressor-Outlet Bleedoff on Turbojet-Engine Performance. William A. Fleming, Lewis E. Wallner, and John T. Wintler. *U.S., N.A.C.A., Research Memorandum No. E50E17*, August 7, 1950. 27 pp., illus. 1 reference.

Test program in the N.A.C.A. Lewis altitude wind tunnel to determine the effect of compressor-outlet bleedoff on the performance of an axial-flow turbojet engine with a variable-area exhaust nozzle at altitudes of 25,000–40,000 ft. and a flight Mach Number of 0.53.

A Method of Presenting the Performance of Turbojet Engines. C. A. Meyer and H. F. Faught. *Aeronautical Engineering Review*, Vol. 10, No. 1, January, 1951, pp. 33–41, illus.

Screens Keep Jet Engines Clean. George L. Christian. *Aviation Week*, Vol. 53, No. 20, November 13, 1950, pp. 42, 43, illus.

Retractable air-intake screen for axial-flow jet engines, built by Smith-Morris Co. Screens are operated by two-power hydraulic actuators. Duct doors are provided in the system to close off the airflow.

New High-Thrust Turbojet Seen for GE. Irving Stone. *Aviation Week*, Vol. 53, No. 23, December 4, 1950, pp. 21, 22, 25–27, illus. Research and production facilities at General Electric's Lynn and Lockland plants; trends of G-E turbine research.

Turbojets—Present and Future. Paul H. Wilkinson. *Aviation Age*, Vol. 14, No. 5, November, 1950, pp. 22, 23, illus. Turbojets in production and under development, 1950–1952.

The Case for the Turbojet. Winnett Boyd. *SAE Journal*, Vol. 58, No. 11, November, 1950, pp. 49–51, illus. 1 reference. (Based on a paper.)

Dart Turboprop Design Accents Long-Life Features. R. N. Dorey. *SAE Journal*, Vol. 58, No. 11, November, 1950, pp. 60–65, illus. (Excerpts from a paper.)

RECIPROCATING (6)

Drag and Cooling Tests in the 24 Ft. Tunnel on a Series of Centaurus Wing Nacelle Installations Suitable for the Buckingham Aircraft. T. B. Owen, H. Shaw, C. Roe, and B. Stockes. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2333*, 1950 (July, 1946). 80 pp., illus. 6 references. British Information Services, New York. $4.15.

Results on a Centaurus 18-cylinder radial air-cooled engine. Cowling types tested are: (1) a conventional N.A.C.A. cowl with a front exhaust ring on the engine and a single exhaust pipe; (2) a similar cowl, with the engine having 18-internal sweptback exhaust pipes terminating at the gill exit; and (3) a cowl with a high-speed entry and an engine exhaust system similar to (2). Results are tabulated.

Quantitative Measurement of Detonation Intensity in Internal Combustion Engines. Gustaf E. V. Jonsson. (*IVA*, 1950, No. 1.) *Acta Polytechnica*, No. 62 (*Mechanical Engineering Series*, Vol. 1, No. 10), 1950. 30 pp., illus. 43 references. Sw. Kr. 3:75. In English.

A method for the objective evaluation of the detonation intensity in which the first differential of pressure is recorded by means of a piezoelectric crystal. The design is insensitive to mechanical vibrations, is operated directly on the cylinder gases, and has an electrical output proportional to the rate of change of pressure. The detonation meter responds only to the high fre-

1936

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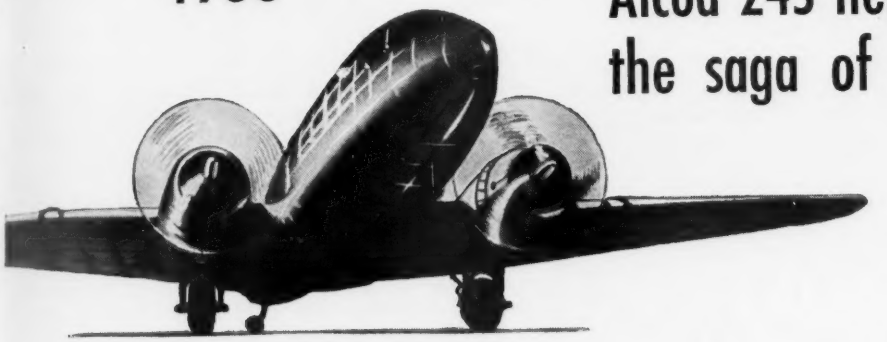

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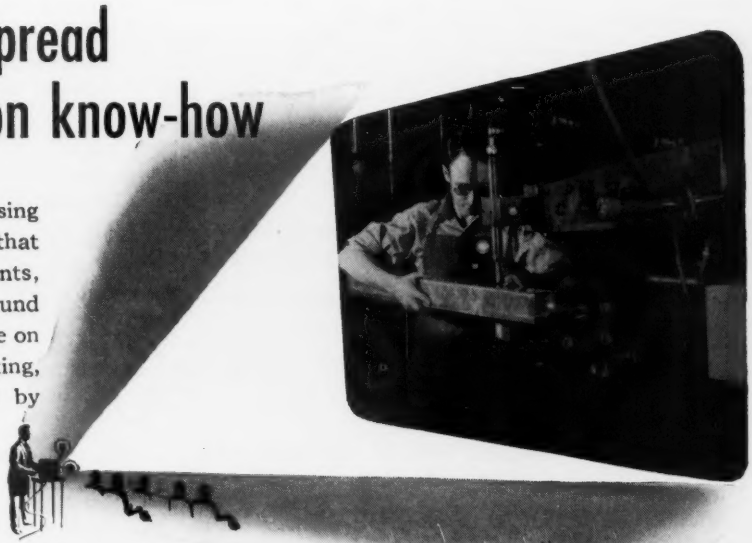

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quencies associated with detonation and not to the pressure changes occurring in normal combustion. The instrument makes it possible to detect extremely weak incipient detonation before the audible knock; detonation intensity is measured quantitatively as a function of the compression ratio.

Radial Engine with Variable Compression and No Master Rod. G. S. Hoell. *Automotive Industries*, Vol. 103, No. 11, December 1, 1950, pp. 44, 45, 102, illus.

Design features of the Sharpe radial engine in which the compression ratio of the engine cylinders could be varied by the pilot in flight. In place of a master connecting rod, this engine has a circular disc suspended on three or more links of equal length.

The Breaking of Valve Springs. P. Kohn. (*Strojnický Obzor*, Vol. 30, No. 5, May, 1950, pp. 67–70.) *The Engineers' Digest*, Vol. 11, No. 10, October, 1950, pp. 358–361, illus.

ROCKET (4)

Engine Selection—A Summary of Opinion. *Shell Aviation News*, No. 148, October, 1950, pp. 23, 24. 15 references.

Brief summary of the opinions of air-line operators and engine manufacturers on the suitability for air-line use of the various types of power plants available.

The Transport of Solid Particles in a Fluid Stream. Wickliffe B. Hendry. *Minnesota, University, Institute of Technology, Engineering Experiment Station, Circular No. 4*, October, 1949. 21 pp. List of 133 references, each with an abstract, including investigations of internal-combustion engine carburetion and manifolding and gas-turbine blade erosion.

An Approximate Method for Estimating the Performance of Oxygen-Oil Rockets. A. B. P. Beeton. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2389*, 1950 (June, 1946). 15 pp., illus. 6 references. British Information Services, New York. $0.75.

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Powdered Iron Blades for Gas Turbines. Joseph Geschelin. *Automotive Industries*, Vol. 103, No. 10, November 15, 1950, pp. 40, 41, 58, illus.

Techniques developed by Thompson Products, Inc., for producing turbine blades from iron powder; the powder is molded to shape in a hydraulic press at a pressure of about 20 lbs. per sq.in. and sintered in a hydrogen atmosphere furnace at 2,000°F. The voids in the metal are filled by the absorption of copper alloy by capillary action. A corrosion-resistant coating of copper-nickel-chromium is electroplated onto the blades.

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Latest Equipment . . . . . at Lockheed. *Automotive Industries*, Vol. 103, No. 7, October 1, 1950, pp. 50–52, illus.

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Latest Developments in Cold Pressure Welding Widen Its Field of Application. William Dubilier. *Materials & Methods*, Vol. 32, No. 5, November, 1950, pp. 78–80, illus. The Koldweld process for welding of nonferrous metals; weld types and applications.

A Survey of Aluminum Welding Techniques. II. Floyd A. Lewis. *The Tool Engineer*, Vol. 25, No. 5, November, 1950, pp. 28–31, illus.

Centrifugal Casting for Critical Components. Herbert Cooper. *Machine Design*, Vol. 22, No. 11, November, 1950, pp. 131, 132, illus.

Improvements and new developments in the centrifugal casting of stainless steel in permanent metal molds meet the rigid requirements of jet aircraft engines and can be applied to pump liners, seat rings, and other critical cylindrical components. Centrifugal case steel has a finer grain than other case steels and exhibits better ductility. Lower unit costs are possible because of the low rejection rate; the surface condition minimizes cleaning costs of the part. Centrifugal casting is economical for bushing and tubular shapes.

Investment-Waxes; Pneumatically-Operated Injection Machine for High-Speed Production. *Aircraft Production*, Vol. 12, No. 145, November, 1950, p. 313, illus.

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Automatic Feathering to Reduce the Hazard of Aircraft Engine Failure at Take-Off. W. L. Kershaw. *Electrical Engineering*, Vol. 69, No. 11, November, 1950, pp. 953–958, illus.

An automatic feathering system used on the Martin 2-0-2 transport aircraft. The feathering cycle is initiated before the pilot has any indication of engine failure, thus eliminating windmilling. Engine torque is used as the means of determining the need for feathering; if the system is arranged for a normal take-off, the propeller will be feathered if engine torque drops below a preset value. A diagram of the automatic feathering circuit shows the connections to manual feathering and unfeathering circuits.

The Determination of Propeller Efficiency in Flight; Preliminary Tests with a Rotol Propeller. K. Eyre. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2414*, 1950 (July, 1950 (July, 1946). 10 pp., illus. 5 references. British Information Services, New York. $0.65.

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Effect of Propeller Thrust on Downwash and Velocity at Tailplane; A Collection of Data from Low Speed Tunnel Tests. A. Spence. *Gt. Brit., Aeronautical Research Council, Current Papers No. 21*, 1950 (August, 1947). 19 pp., illus. 4 references. British Information Services, New York. $0.40. Data from low-speed wind-tunnel tests on the longitudinal stability of five propeller models are plotted and tabulated.

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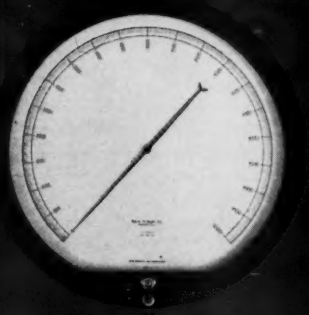

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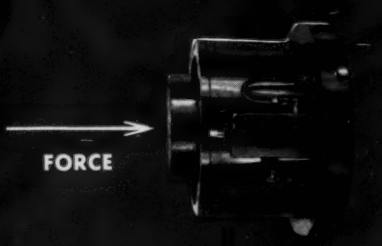

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Development of an electronic differential analyzer using the basic operations of addition, subtraction, integration, and differentiation. These operations are performed by feedback networks with high-gain d.c. amplifiers; a series of these units are combined to form a flexible analyzer. The machine is limited to the solution of linear and simultaneous linear differential equations; solution of more complex differential equations requires the development of a process for the electronic multiplication of two variables. Appendixes to this preliminary report contain detailed studies of the adding and integrating units.

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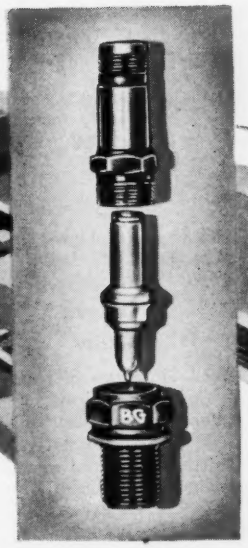

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Basic principles of an electronic simulator that solves the equations for coupled oscillations in several degrees of freedom. Electronic amplifiers are used as adding and integrating units; the method of representing simple harmonic motion is given. The problem of coupling two or more groups of amplifiers to correspond to two or more degrees of freedom is examined. A prototype machine for the solution of problems with two degrees of freedom is being built at the R.A.E.; a simulator is being designed for problems involving six degrees of freedom.

Report on an Investigation of Stresses in Aircraft Structures Under Dynamic Loading for the Bureau of Aeronautics. R. L. Bisplinghoff, G. Isakson, T. H. H. Pian, H. I. Flomenhoft, and T. F. O'Brien. *Massachusetts Institute of Technology, Department of Aeronautical Engineering, Aero-Elastic and Structures Research, Contract No. NOa(s) 8790*, January 21, 1949. 377 pp., illus. 76 references.

The mathematical approach to the problem of determining the transient stresses in damped and undamped elastic structures is based on Lagrange's equation of motion and the related concept of the use of displacements of natural modes of vibration as generalized coordinates. The airplane structure is replaced by a dynamic model having a finite number of degrees of freedom. A system of homogeneous total differential equations defining the free vibrations of the system are determined from the inertia and elastic properties of the dynamic model. The mode shapes and frequencies are obtained from the characteristic values of this system by a matrix iteration process. The modes and frequencies are calculated for a Lockheed XR60-1 wing and a wing with 45° sweepback. In the determination of the effect of aerodynamic forces on the transient stresses in an airplane structure during landing, a mechanical analyzer was designed and built. The analyzer was used to obtain the time history of the stresses due to rapidly applied loads when damping forces are neglected. An analysis of the gust problem by this method shows that the response of a system to gusts of arbitrary shape can be obtained by superposition from the response to a sharp-edged gust. The general method is further extended to obtain the effect of a gun blast on the airplane structure.

Nonlinear Effects of Structural Deformation on Stability. Albert Epstein. *Journal of the Aeronautical Sciences*, Vol. 18, No. 1, January, 1951, pp. 50–54, illus. 6 references. Analysis of the effect of skin buckling on longitudinal stability and its influence on control forces.

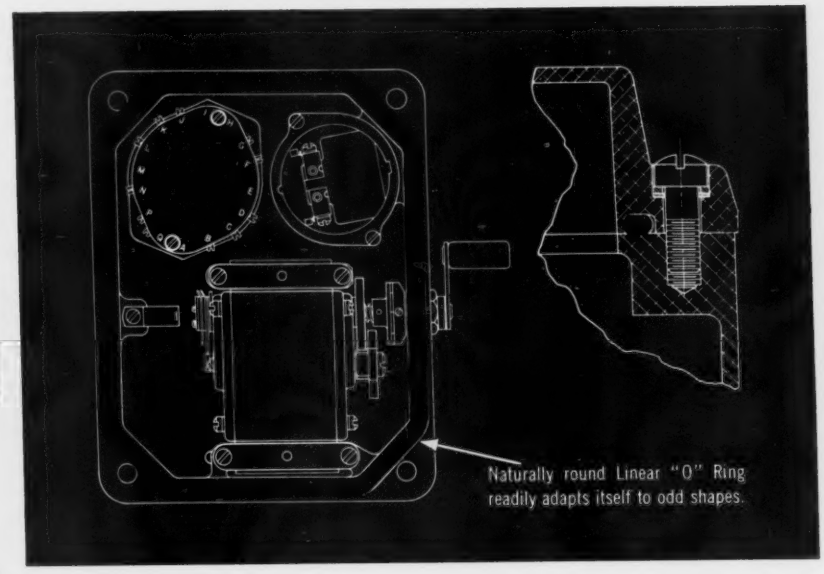
An Analysis of the Response of a Damped Dynamical System Subjected to Impressed Forces. R. W. Traill-Nash. *Australia, Department of Supply and Development, Aeronautical Research Laboratories, Report No. SM. 151*, May, 1950. 31 pp., illus. 8 references.

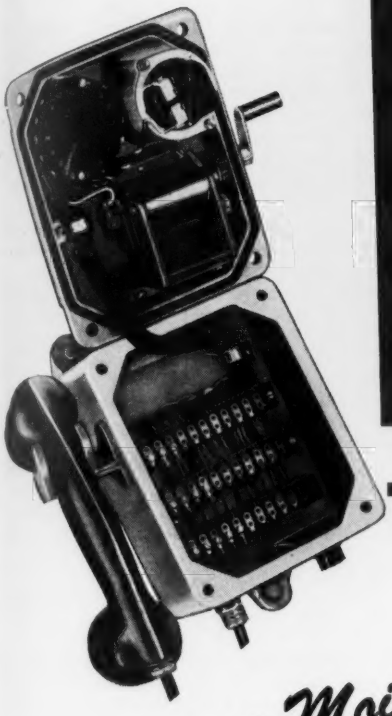
Analysis of dynamic system, which is assumed to be harmonic and without body freedoms, with arbitrary viscous damping distribution. The solution, which is obtained by the use of modes of damped vibration, consists of displacement relating to the instantaneous value of the impressed forces and displacement expressed as the sum of the damped natural mode components. The application of the method is severely limited by the neglect of damping considerations; it does not apply to the problem of aircraft gusts. This method of solution is extended for a damped holonomic system without cyclic coordinates.

Antisymmetrical Flutter of a Large Transport Aeroplane. W. Prichard Jones. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2363*, 1950 (July, 1944). 13 pp., illus. 4 references. British Information Services, New York. $1.60.

Investigation of the effect of antisymmetric-flexure aileron flutter on the fuselage in roll and on the elasticity of the wings in torsion. The dynamic equations are derived for the system with four degrees of freedom. The modes are parabolic in flexure and linear in torsion. The process is applied numerically for a typical wing.

The Investigation of Air Loads in Flight from Measurements of Strain in the Structure. J. Taylor. *Gr. Brit., Aeronautical Research Council, Reports and Memoranda No. 2408*, 1950 (Novem-





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ber, 1945). 4 pp., illus. 2 references. British Information Services, New York. $0.30.

For most in-flight measurements, the overall bending and shear actions are required for approximately five stations on each major component. Four to eight measurements at each station should be sufficient if the proper gage positions are used.

Gust Loads on Rigid Airplanes with Pitching Neglected. R. L. Bisplinghoff, G. Isakson, and T. F. O'Brien. *Journal of the Aeronautical Sciences*, Vol. 18, No. 1, January, 1951, pp. 33–42, illus. 17 references.

Analysis of the motion of a rigid aircraft flying into a linearly graded gust. The solution is presented in the form of an alleviation factor, which is a function of the mass parameter and of the relationship between the gust gradient distance and the airplane chord. Flight at high subsonic and at supersonic speeds is considered.

Isolated Force Problems in Two-Dimensional Elasticity (I). M. Rothman. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 3, Part 3, September, 1950, pp. 279–296, illus. 4 references.

Solution of the problems of one or more isolated forces on the boundaries of holes of various shapes in an infinite plate by expressing the stresses and displacements in terms of two potentials, $\Omega(z)$ and $\omega(z)$.

An Approximate Method for the Calculation of the Stresses in Sweptback Wings. Thorkild Rand. *Journal of the Aeronautical Sciences*, Vol. 18, No. 1, January, 1951, pp. 61–63, illus. 4 references.

An approximate method is proposed to eliminate the error that arises when groups of stringers are replaced by a few imaginary longerons in order to reduce the number of statically indeterminate quantities in monocoque structures. The idea underlying the method is to choose arbitrarily a limited number of degrees of freedom of motion and to consider the corresponding self-equilibrating groups of forces as the statically indeterminate quantities.

Structural Efficiency of Wings. J. Solvey. (*Australia, Council for Scientific and Industrial Research, Division of Aeronautics, Report No. SM. 107*, January, 1948.) *Australia, Department of Supply, Aeronautical Research Consultative Committee, Report No. ACA-44*, March, 1949. 41 pp., illus. 5 references.

Determination of the criterion of wing structural efficiency, which is the ratio of structural air weight of an ideal wing to the design weight of the aircraft. This report is essentially a review and extension of Cox's work on the criterion. The problems of a wing that does not carry any concentrated loads is considered, and corrections are added to make the ideal wing approximate more nearly the actual wing.

A Review of Some Basic Types of Geometric Stress Concentration. D. A. Lemaire. (*Australia, Council for Scientific and Industrial Research, Division of Aeronautics, Report No. SM. 126*, May, 1949.) *Australia, Department of Supply, Aeronautical Research Consultative Committee, Report No. ACA-48*, September, 1949. 20 pp., illus. 28 references.

Aérosudest SE-2010 Armagnac Four-Engined Transport, France. James Hay Stevens. *Aircraft Engineering*, Vol. 22, No. 261, November, 1950, pp. 318–322, illus.

Method of testing and results of tests on the fuselage, nose, wing, central portion of the fuselage, and the tail section with the fin and half the tail plane of the Armagnac. The test rig consists of standard welded steel columns that can be placed wherever they are needed. The load is applied by electrically-operated screw jacks through tie-rods and chains. Tensometers attached to each load strap give individual measurements; a central test panel records the entire test.

The Structural and Aerodynamic Effects of Wing Thickness and Fuselage Size Variation. A. G. Pugsley, W. Tye, and H. J. Allwright. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2377*, 1949 (January, 1940). 10 pp., illus. British Information Services, New York. $0.50.

The Influence of Wing Geometry and Structural Efficiency on Aircraft Performance. J. Solvey. (*Australia, Council for Scientific and Industrial Research, Division of Aeronautics, Report No. SM. 119*, October, 1948.) *Australia, Department of Supply, Aeronautical Research Consultative Committee, Report No. ACA-45*, March, 1949. 25 pp., illus. 2 references.

Investigation of the effect of wing plan form and thickness variation on wing-structure weight and aircraft performance with the use of the criterion of wing structural efficiency. Results are given in curves for four airplanes: fighter type, bomber type, and two civil transport types.

Summarized Proceedings of a Conference on Stress Analysis, London, 1950. E. K. Frankl. *British Journal of Applied Physics*, Vol. 1, No. 10, October, 1950, pp. 241–251, illus. 3 references.

Readers' Forum: Discussion on "The Solution of Elastic Problems by Electronic Analog Computation." R. H. MacNeal, G. D. McCann, and C. H. Wilts. *Journal of the Aeronautical Sciences*, Vol. 18, No. 1, January, 1951, p. 71.

A Solution to the Problem of Torsion-Flexure. R. L. Mordelet. *Aircraft Engineering*, Vol. 22, No. 261, November, 1950, pp. 335–337, illus. The method of solution uses the principle of least work and the calculus of variations to establish the potential-energy integrals.

The Equilibrium of Thin Elastic Shells. A. E. Green and W. Zerna. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 3, Part 1, March, 1950, pp. 9–22. 18 references.

The theory of thin elastic shells is developed as a first approximation using vector and tensor notations and general coordinates. The normals to the middle surface of the undeformed shells are not considered to be also normals to the deformed shells. The shell is assumed to be of constant thickness.

The Stresses in a Flat Panel Under Shear When the Buckling Load Has Been Exceeded. D. M. A. Leggett. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2430*, 1950 (September, 1940). 17 pp., illus. 5 references. British Information Services, New York. $0.90.

Bending of an Elliptic Plate with a Confocal Hole. B. R. Seth. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 2, Part 2, June, 1949, pp. 177–181. 7 references.

The Formation and Enlargement of a Circular Hole in a Thin Plastic Sheet. G. I. Taylor. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 1, Part 1, March, 1948, pp. 103–124, illus. 3 references.

On the Plane Stress-Distribution in an Infinite Plate with a Rim-Stiffened Elliptical Opening. A. A. Wells. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 3, Part 1, March, 1950, pp. 23–31, illus. 5 references.

An exact and rational solution is obtained for an elliptical opening stiffened with a homogeneous rim when the area of cross section of the rim follows a distribution around the opening which depends on the eccentricity of the ellipse and on the amount of stiffening. Calculations may be carried out for any particular point by use of the value of the rim parameter at that point and by using St. Venant's principle. Solutions are obtained for hydrostatic tension and pure shear in two directions at infinity.

The Bending of a Uniformly Loaded Clamped Plate in the Form of a Circular Sector. H. R. Hasse. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 3, Part 3, September, 1950, pp. 271–278. 2 references.

The deflection is obtained by Weinstein's method, which requires the solution of a biharmonic equation subject to specific boundary conditions. The theoretical justification of the method is not given.

On the Analogues Relating Flexure and Extension of Flat Plates. R. V. Southwell. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 3, Part 3, September, 1950, pp. 257–269. 5 references. An analysis to show that the extension and flexure of flat plates are problems that should not be treated separately because mathematically they are identical.

A Theory of the Plastic Bulging of a Metal Diaphragm by Lateral Pressure. R. Hill. *Philosophical Magazine*, Vol. 41 (7th Series), No. 322, November, 1950, pp. 1133–1142, illus. 4 references.

Explicit formulas are obtained for the stresses in a metal diaphragm that is bulged plastically by lateral pressure. The predicted influence of work-hardening on the shape of the profile, and on the relation between polar strain and curvature, agrees well with experimental data. A simple expression is developed for the instability strain.

Analysis of Pin-Jointed Redundant Plane Frameworks Using Equivalent Elastic Systems. Leroy A. Beaufoy ad A. F. S. Diwan. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 3, Part 1,March, 1950, pp. 32–50, illus. 1 reference.

Photo-Elastic Examination of Local Stress Variations. I—A Photo-Elastic Examination of Local Stress Variations in Tension Members of Rectangular Cross Section in the Neighbourhood of Rivets. II—Photo-Elastic Determination of Shear Load in

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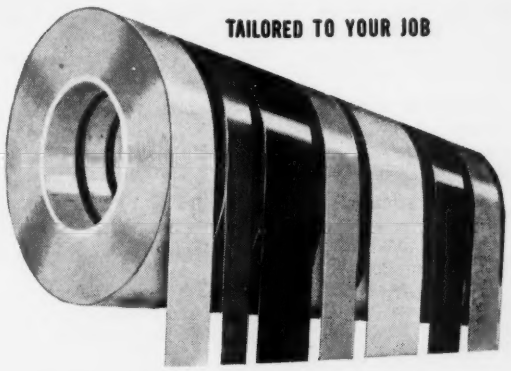

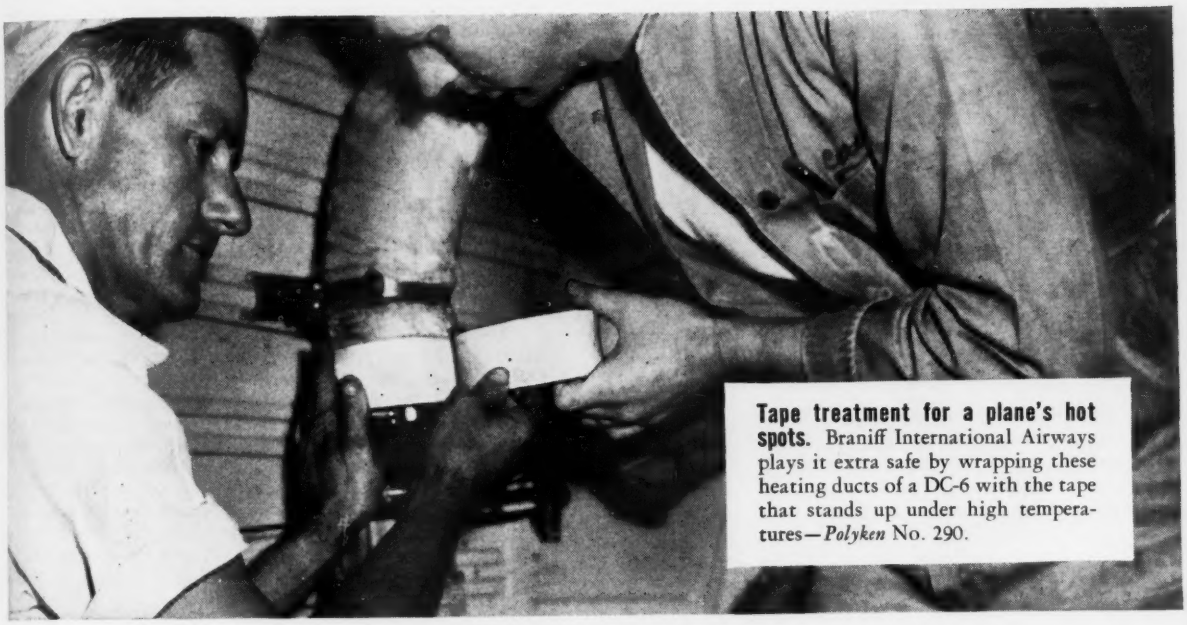

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Bolts by Means of the "Freezing" Method. W. A. P. Fisher. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2378*, 1950 (February, 1946). 19 pp., illus. 10 references. British Information Services, New York. $1.00.

Analysis of Continuous Structures by the Stiffness Factor Method. Leroy A. Beaufoy and A. F. S. Diwan. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 2, Part 3, September, 1949, pp. 263–282, illus. 2 references.

The Approximate Design of Small Rigid-Frame Structures. F. S. Shaw. *Australia, Department of Supply and Development, Aeronautical Research Laboratories, Report No. SM. 153*, June, 1950. 30 pp., illus.

Development of formulas covering most requirements of small rigid-frame structures, based on the results of computed examples. They can be easily solved with a slide rule and afford a rapid method of design calculations.

Buckling of Continuous Beams on Elastic Supports. J. M. Klitchieff. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 2, Part 3, September, 1949, pp. 258–262, illus. 2 references.

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Stress and Distortion Analysis of a Swept Box Beam Having Bulkheads Perpendicular to the Spars. Richard R. Heldenfels, George W. Zender, and Charles Libove. *U.S., N.A.C.A., Technical Note No. 2232*, November, 1950. 90 pp., illus. 9 references.

The Anticlastic Curvature of Rectangular Beams and Plates. D. G. Ashwell. *Royal Aeronautical Society, Journal*, Vol. 54, No. 479, November, 1950, pp. 708–715, illus. 4 references.

A study of the nature of the distortions of the cross sections of rectangular beams of any dimensions, and of the transition process between curvature and bending. The fundamental equations for distortion are derived. The solutions obtained are compared with the usual theory, using the deflection of a beam at its edges as the standard.

The Distribution of Stress in the Neighbourhood of a Crack. T. J. Willmore. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 2, Part 1, March, 1949, pp. 53–62, illus. 9 references.

A Theoretical and Experimental Investigation of a Dynamically Loaded Ring with Radial Elastic Support. Edward Wenk. *U.S., Navy Department, David W. Taylor Model Basin, Report No. 704 (NS 870-001)*, July, 1950. 71 pp., illus. 43 references.

The Plastic Yielding of Notched Bars Under Tension. R. Hill. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 2, Part 1, March, 1949, pp. 40–52, illus. 14 references.

On the Computation of Strain and Displacement in a Prism Plastically Strained by Torsion. R. V. Southwell. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 2, Part 4, December, 1949, pp. 385–397, illus. 14 references.

The Use of the Mellin Transform in Finding the Stress Distribution in an Infinite Wedge. C. J. Tranter. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 1, Part 2, June, 1948, pp. 125–130, illus. 8 references.

Designing Tubes for Bending Loads. George E. Allison and Alfred Salem Niles. *Machine Design*, Vol. 22, No. 11, November, 1950, pp. 163–165, illus. 1 reference.

A direct procedure for the selection of the proper size of tubing for a specific bending load involves the correct combination of pertinent relationships and the use of data sheet given in the article. The lightest-weight tube can be selected from the data sheet if the maximum diameter-thickness ratio and its relationship to the modulus of rupture are known. Simple methods are outlined for computing the margin of safety for the tube and for obtaining the relative weights of tubes of different materials.

Thermodynamics (18)

Heat-Transfer and Flow-Friction Characteristics of Some Compact Heat-Exchanger Surfaces. I—Test System and Procedure. II—Design Data for Thirteen Surfaces. W. M. Kays and A. L. London. *American Society of Mechanical Engineers, Transactions*, Vol. 72, No. 8, November, 1950, pp. 1075–1097, illus. 19 references.

I. Test apparatus and method of analysis. Results of test data on a louvered-plate-fin heat-exchanger surface illustrate the accuracy of the test data. II. Design data for 13 surfaces of the plate-fin type and the finned-flat-tube type. The surfaces are compared on the basis of heat-transfer coefficient vs. flow-friction horsepower.

On the Theory of the Propagation of Detonation in Gaseous Systems. Y. B. Zeldovich. (*Zhurnal Experimental'noi i*

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Teoreticheskoi Fiziki, U.S.S.R., Vol. 10, 1940, pp. 542–568.) *U.S., N.A.C.A., Technical Memorandum No. 1261*, November, 1950. 50 pp., illus. 43 references. Analysis of the existing theory of detonation.

Flame Propagation. I—The Effect of Initial Temperature on Flame Velocities of Propane-Air Mixtures. Gordon L. Dugger. *American Chemical Society, Journal*, Vol. 72, No. 11, November, 1950, pp. 5271–5274, illus. 14 references.

Experiments conducted at the N.A.C.A. Lewis Flight Propulsion Laboratory to determine the flame velocity as a function of composition at various temperatures by the Bunsen burner method Test data are correlated with a thermal and a diffusion theory.

Theory of Combustion and Detonation of Gases. Y. B. Zeldovich. Translation from the Russian Prepared by Brown University, Graduate Division. (*Akademiia Nauk S.S.S.R., Leningrad, Institut Khimicheskoi Fiziki*, 1944.) *U.S., Air Force, Translation No. F-TS-1226-IA* (*GDAM A9-T-45*), May, 1949. 118 pp., illus. 56 references.

A theoretical explanation is given of the unique effects that take place in the combustion of mixtures containing gases of different molecular weights. The dependence of combustion limits on the direction of flame propagation is studied in lean hydrogen mixtures. The study of detonation clarifies the conditions under which chemical reactions take place. A theory of detonation is presented, and this theory is applied to a series of problems in the chemistry of high temperatures.

Analysis of Turbulent Free-Convection Boundary Layer on Flat Plate. E. R. G. Eckert and Thomas W. Jackson. *U.S., N.A.C.A., Technical Note No. 2207*, October, 1950. 22 pp., illus. 9 references.

The flow and heat transfer for a fluid with a Prandtl Number close to unity was calculated by the use of von Kármán's approximate method. Formulas are derived for the heat-transfer coefficient, for the maximum velocity in the boundary layer, and for the boundary-layer thickness.

Graphical Method for Obtaining Flow Field in Two-Dimensional Supersonic Stream to Which Heat Is Added. I. Irving Pinkel and John S. Serafini. *U.S., N.A.C.A., Technical Note No. 2206*, November, 1950. 62 pp., illus., 2 fold. charts. 3 references. The charts cover a Mach Number range of 1.3–5.0.

Loss Coefficients for Abrupt Changes in Flow Cross-Section with Low Reynolds Number Flow in Single and Multiple-Tube Systems. W. M. Kays. *American Society of Mechanical Engineers, Transactions*, Vol. 72, No. 8, November, 1950, pp. 1067–1074, illus. 11 references.

A theory for evaluating the flow-contraction- and expansion-loss coefficients for various contraction and expansion ratios based on the contraction-and-expansion-area ratio of the velocity distribution. Experimental results at Reynolds Numbers of 500–20,000 agree well with the theory. The theory for the expansion coefficient is an extension of the Borda-Carnot analysis allowing for nonuniformity of velocity distribution at both upstream and downstream sections. The theory for the contraction coefficient is an extension of the expansion coefficient analysis. The idealized system analysis is applied to geometries corresponding to some high-rating heat-exchanger surfaces.

Readers' Forum: Calculation of the Thermal Boundary Layer of a Body in Incompressible Laminar Flow. W. Dienemann. *Journal of the Aeronautical Sciences*, Vol. 18, No. 1, January, 1951, pp. 64, 65, illus. 9 references.

Water-Borne Aircraft (21)

Maximum Impact Pressures on Seaplane Hull Bottoms. A. G. Smith, I. W. McCaig, and W. M. Inverarity. *Gt. Brit., Aeronautical Research Council, Current Papers No. 4*, 1950. 110 pp., illus. 12 references. British Information Services, New York. $1.70.

Investigation of the effect of various impact parameters on the maximum impact pressures, using three hulls (each 3 ft. long) with dead rise angles of 10°, 20°, and 30° under controlled speed, attitude, and acceleration conditions. Theoretical studies were carried out on the effect of maximum pressure on the size of measuring surface, beam loading, freedom to pitch, horizontal velocity, initial vertical acceleration, and departure from the simple wedge shape. Test results are tabulated and plotted. A comparison is made between some of the test results and computed pressure values.

Determination of the Static Stability of Seaplanes. K. M. Tomaszewski. *Gt. Brit., Aeronautical Research Council, Current Papers No. 14*, 1950 (June, 1946). 53 pp., illus. 14 references. British Information Services, New York. $1.90.

Graphic methods for the determination of the effects of any known statically or dynamically applied forces or moments in any known sea and wind conditions. The methods give a complete picture of the nature of the buoyancy forces at rest and at low taxiing speeds. The process is worked out for a small twin-float seaplane; the layouts and graphs used are a guide to further applications.

Hydrodynamic Design of Seaplane Floats. K. M. Tomaszewski. *Gt. Brit., Aeronautical Research Council, Current Papers No. 15*, 1950 (November, 1946). 60 pp., illus. 16 references. British Information Services, New York. $1.25. Design of floats and their method of attachment to the hull on the basis of existing data and tank tests.

Progress Report on Research in Frictional Resistance. *U.S., Navy Department, David W. Taylor Model Basin, Report No. 726* (*NS 715-086*), September, 1950. 61 pp., illus. 39 references.

Contents: Note on Studies of the Resistance of Hydraulically-Rough Surfaces, Philip Eisenberg. A Review of the Theory of the Frictional Resistance of a Smooth Flat Plate with Turbulent Boundary Layer, L. Landweber. Effect of Transverse Curvature on Frictional Resistance, W. M. Ellsworth, Jr. The Boundary Layer and Drag of Bodies of Revolution, P. S. Granville. Recent Progress in Hot-Wire Measurement of Turbulence in Water, M. S. Macovsky and W. L. Stracke. Model Basin Turbulence, M. S. Macovsky and W. L. Breslin. Effects of Turbulence Stimulation on the Boundary Layer and Resistance of a Ship Model As Detected by Hot Wires, J. P. Breslin and M. S. Macovsky. Experimentation to Develop Suitable Methods for Stimulating Turbulent Flow About Ship Models, R. B. Couch and W. B. Hinterthan. A Study of Rods as Simulators of Turbulence in Boundary Layers, M. S. Macovsky and J. P. Breslin. On the Acoustic Stimulation of Turbulence, M. St. Denis.

Analysis of Wave Resistance. Georg P. Weinblum. *U.S., Navy Department, David W. Taylor Model Basin, Report No. 710*, September, 1950. 102 pp., illus. 116 references.

Effects of Turbulence Stimulators on the Boundary Layer and Resistance of a Ship Model As Detected by Hot Wires. John P. Breslin and Morris S. Macovsky. *U.S., Navy Department, David W. Taylor Model Basin, Report No. 724* (*NS 715-086*). August, 1950. 40 pp., illus. 17 references.

An Instrument for Directly Recording the Metacentric Height of a Ship. A. G. Boggis and E. C. B. Corlett. *Journal of Scientific Instruments*, Vol. 27, No. 10, October, 1950, pp. 278, 279, illus.

On the Waves Due to the Rolling of a Ship. F. Ursell. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 1, Part 2, June, 1948, pp. 246–252. 4 references.

On the Rolling Motion of Cylinders in the Surface of a Fluid. F. Ursell. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 2, Part 3, September, 1949, pp. 335–352, illus. 10 references.

On the Heaving Motion of a Circular Cylinder on the Surface of a Fluid. F. Ursell. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 2, Part 2, June, 1949, pp. 218–231. 6 references.

The Wave Resistance of a Cylinder Started from Rest. T. H. Havelock. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 2, Part 3, September, 1949, pp. 325–334, illus. 3 references.

The Resistance of a Submerged Cylinder in Accelerated Motion. T. H. Havelock. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 2, Part 4, December, 1949, pp. 419–427, illus. 3 references.

Wind Tunnels & Research Facilities

Hypersonic Research Facilities at the Ames Aeronautical Laboratory. Victor I. Stevens. *Journal of Applied Physics*, Vol. 21, No. 11, November, 1950, pp. 1150–1155, illus. 3 references.

Description of the N.A.C.A. 10- by 14-in. supersonic tunnel and the supersonic free-flight tunnel, their related equipment, and test techniques. The 10- by 14-in. tunnel is capable of speeds equal to a Mach Number of 3.5–8.0. In the free-flight tunnel,

(*Continued on page 94*)

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Aeronautical Reviews — BOOKS

Foundations of Aerodynamics

By A. M. Kuethe and J. D. Schetzer. New York, John Wiley & Sons, Inc., 1950. 374 pp., figs. $5.75.

Since the development of modern high-speed aircraft during the last decade or so, the field of aerodynamics has been expanded at an extremely rapid pace. The classical aerodynamics theory, based on the assumption of inviscid incompressible fluid, is found inadequate to describe the flow phenomena, and the effects of viscosity, turbulence, and compressibility must be taken into account. Fifteen or twenty years ago, an aerodynamicist had to know only the relatively simple results of incompressible flow to design a good plane. Today, the subject of aerodynamics has become so complicated that few aeronautical engineers can keep abreast of all its phases. The teaching of aerodynamics at the same time also becomes an increasingly difficult task where the teacher must select the material in a careful and discriminating manner to enable the students to have a perspective view of the entire field and to have a good foundation from which they can later specialize in any of its phases. Older textbooks appear to become inadequate for their lack of newer information. The majority of new books on aerodynamics published after the war have specialized mainly on compressible or supersonic flows. There is indeed a need for a book such as the one written by Professors Kuethe and Schetzer in which all phases of aerodynamics are well covered.

The book contains 18 chapters. The first chapter gives a general description of the fluid medium, the property of gas at rest, standard atmosphere, viscosity, and the approximation involved in the formulation of the fluid problems. The next five chapters are devoted to a study of the flow of a perfect fluid and to the application of perfect fluid theory to the prediction of the lifting characteristics of thin airfoils and the finite wing.

Chapters 7 to 11 deal with the compressible inviscid fluid and its application to the flow through channels and about the wings. The characteristics of wings in subsonic flow are shown to be well described by a correction factor to the perfect fluid results. In supersonic flow, the characteristics are presented by an approximation that removes the nonlinear terms in the differential equations that describe the flow. Shock waves are described briefly.

The effects of viscosity on the flow of an incompressible fluid are taken up in chapters 12 through 16. Here the flow in boundary layers and tubes is treated. The main objectives are to give an understanding of the approximations that have been made in the perfect fluid theory and to analyze the problems of viscous drag and flow separation. Chapter 17, on viscous compressible fluids, concerns mainly the alterations to the boundary layer which are due to compressibility and also the effects of viscosity on the flow of a compressible fluid. The last chapter discusses the application of the principles taken up in the preceding chapters to certain practical problems of wing design and stalling and three-dimensional effects.

The book has been excellently written and well organized. It is suitable as a textbook in senior aerodynamics courses or a first course in graduate aerodynamics. The authors are to be congratulated for having been able to give such a comprehensive coverage in a remarkably clear and concise manner.

DR. C. T. WANG
Associate Professor of Aeronautical Engineering
College of Engineering
New York University

The Friction and Lubrication of Solids

By F. P. Bowden and D. Tabor. London, Oxford University Press, 1950. 337 pp., figs. $7.00.

No man or group of men has done more to elucidate the mechanism of friction of solids than have the authors of this book and their colleagues in the Laboratory on the Physics and Chemistry of Rubbing Solids, Cambridge, England. Two decades ago the theory ascribing frictional phenomena to the mechanical interlocking of surface irregularities was replaced by one describing friction force in terms of adhesion of the atoms comprising the surfaces of the sliding bodies. The authors have since made a major contribution to the field by revising the adhesion theory to emphasize the importance of the bulk properties of the solid, rather than considering the friction to be purely a surface effect.

This book is basically a monograph describing the research conducted by the authors and their coworkers during the last 15 years. It should be emphasized that the work is confined to dry and boundary-lubricated solids and does not include studies in full-fluid or hydrodynamic lubrication, this subject having received ample treatment from other workers since the time of Tower and Reynolds.

The opening chapters deal with those factors that are common to all solid friction processes. Here the reader learns that the area over which surfaces make time contact is but a small fraction of the nominal or apparent area and that the true area is determined by plastic flow of the surface asperities. Relative sliding of the surfaces is shown to result in extremely high temperatures at these minute points of contact, even though the temperature rise in the bulk of the solid is negligible. As a result of the local high temperatures and pressures, minute welds are formed at the points of true contact, and it is found that the force required to shear these junctions constitutes the major portion of the observed friction force. Surface damage resulting from this process is discussed at some length, as is the beneficial effect of adventitious films of oxide and adsorbed gases in preventing excessive friction and damage.

The complex but technologically important subject of boundary lubrication is amply treated, and, among other things, it is shown that, contrary to earlier views, physically adsorbed monolayers of lubricant alone will not provide optimum lubrication. The superior lubricating quality of the fatty acids is found to be due to

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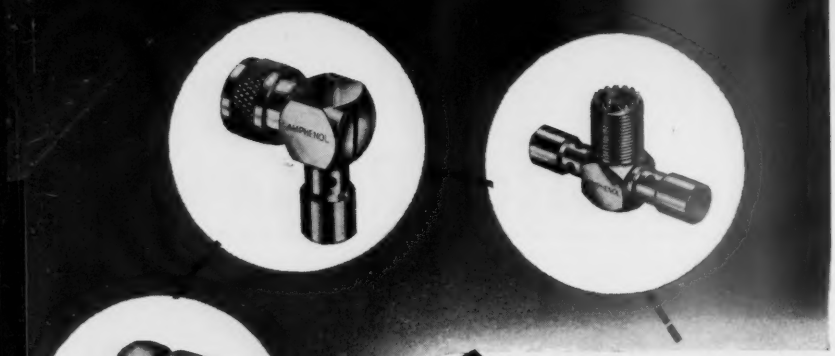

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chemical reaction between the acid and the surface to form a metallic soap, which in turn has physical properties resulting in low friction. Experiments suggest that the presence of water and oxide films on certain metal surfaces is of importance in promoting the required chemical attack by the fatty acid. The mechanism of extreme pressure lubrication is discussed, and data are presented to illustrate the efficacy of typical E.P. lubricants in cutting and drawing operations.

Succeeding chapters deal with such diverse topics as the nature of contact between colliding solids, the influence of liquid films on the adhesion between solid surfaces, and chemical reactions produced by friction and impact. A chapter on metallic wear is included but leaves much to be desired. This does not reflect upon the authors but is indicative of the general lack of fundamental research on the wear process.

Generally speaking, the book is well written, contains ample references to the work of other men in the field, and is well illustrated where necessary. Although the complex nature of the subject calls for the application of knowledge and techniques from a wide range of sciences, sufficient background material has been supplied in most cases to permit the nonspecialist to read and understand the subject with a minimum of effort. It is the most complete work on friction and boundary lubrication in existence and should be of interest to all engineers interested in, or beset by, problems concerning frictional phenomena.

CHARLES D. STRANG, JR.
Research Associate in
Mechanical Engineering
Massachusetts Institute of
Technology

Introduction to Helicopter Aerodynamics

Volume 1, Performance. By W. Z. Stepniewski, Morton, Pa., Rotorcraft Publishing Committee, 1950. 157 pp., figs. $2.50.

The Rotorcraft Publishing Committee, ten names including the author, announces this booklet as the initial volume in what is hoped will be a complete series of works on rotary-wing aircraft. The booklet originated in a series of weekly lectures on helicopter aerodynamics which the author gave at the Piasecki Helicopter Corporation during the winter of 1947–1948.

The volume begins with a brief review of aerodynamic fundamentals such as Bernoulli's theorem, Kutta-Joukowski theorem, explanations of induced drag, Reynolds Number effects, compressibility effects, etc.—a total of 40 pages.

The second chapter is entitled "Simple Momentum Theory" and treats the helicopter rotor in hovering, vertical climb, and forward flight as

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an actuator disc making use of Glauert's concept of momentum theory in forward flight. The author mentions the fact that no mathematical proof of this concept can be offered as yet, except for high forward velocity where Glauert's momentum theory results in the same induced loss as the elementary wing theory applied to a wing of circular plan form. A skeptical student, at this point, might be relieved to learn that, in spite of the missing mathematical proof, Glauert's momentum concept leads to results that are in good agreement with wind-tunnel and flight measurements. The absence of references to experimental results is a peculiarity of this booklet, possibly in order not to disturb the elementary character of the volume. For the more critical student, however, a number of questions will be left open.

The third chapter gives an introduction to the blade-element theory and its combination with the simple momentum theory, both for vertical and forward flight.

The chapter following is a brief review of the propeller vortex theory, limited to vertical flight conditions.

The fifth chapter is entitled "Practical Methods of Calculating Rotor Thrust and Power in Hovering and Vertical Flight." After a discussion of methods to determine the effect of blade-tip losses, equations for thrust and power required are derived, assuming the concept of the combined momentum and blade element theory. The chapter following includes a discussion of the effect of design parameters on the performance in hovering and vertical ascent. The optimum rotor radius is determined which is required for given blade tip speed, blade solidity ratio, and gross-weight minimum power in hovering. The critical student probably would appreciate a remark that the actual problem of determining the optimum rotor radius is more involved and includes design data of the effect of rotor radius on the helicopter weight, etc. Data on hovering in ground effect are given on the basis of recent British tests.

The seventh chapter covers the performance analysis of the helicopter in forward flight using the simplified concept and the notation of Glauert and Squire. The more modern and more accurate work of the N.A.C.A. is not mentioned, probably in order to keep the line with the elementary character of the book. The last chapter is devoted to the problem of vertical autorotation and is based mainly on Hafner's work.

There certainly is a need for good textbooks on helicopter aerodynamics and dynamics, and, in spite of some shortcomings, this booklet is an encouraging beginning. The publications of the Rotorcraft Publishing Committee announced for the future will be awaited with interest.

KURT H. HOHENEMSER
Chief of Aerodynamics
Helicopter Division
McDonnell Aircraft Corporation

The Psychology of Flight

By Alex Varney. New York, D. Van Nostrand Company, Inc., 1950. 269 pp. $3.75.

Alex Varney has had a long career as a flight instructor, starting in the days of the World War I training planes and the early trimotors. This book has been written as a guide to the emotional and physical factors that condition the human being's response to air-borne movement. It is offered to be helpful to all who use the medium of air as a medium of transportation—the flight instructor, professional pilot, student pilot, and the aircraft passenger.

In this book the author writes with considerable clarity and detail of the many psychoses that assail and afflict the human, not only in air travel but in many instances in everyday life. In many cases, the reader will feel as he reads that he is, and has been, aware of a specific psychosis mentioned. However, being aware of it and doing something constructive about it are two different things. This book should help in accomplishing the latter.

From the layman or student's point of view, two matters should be mentioned. The first is the reiterated cure of breaking down a problem into its various steps, then performing and concentrating on each step in sequence. Although that is the ultimate way to a solution, the usual trouble is that the student or layman has no way to recognize the steps or logical divisions of a problem. The professional knows what to practice, but the student must be shown and taught what to practice. In regard to this, I find that this book falls short.

A second point is the continuous use of examples calling for the extreme penalty as the payment for committing errors. I am sure this would tend to deter the student or layman in his pursuit to enjoy aircraft manipulation or travel. It certainly should heighten a psychosis already had by those making their first ventures, usually timorously, into the air, if not set up a new psychosis.

I recommended this book most specifically to those engaged in teaching the art of flying. For them it is excellent. If followed, it should make them better teachers through their understanding of the inner workings of their students. I also recommend it for the professional pilot to help him develop a more stable and more efficient behavior pattern. It should also aid him as well as the instructor to understand passengers better. I feel, however, that the student and the layman might find themselves more confused and awed by the complexities involved and more fearful of air travel because of the extreme-penalty clause invoked.

JOSEPH P. RYAN
Manager of Publications
I.A.S.

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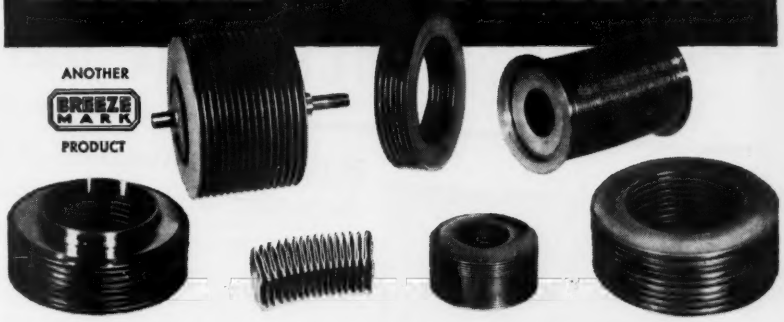

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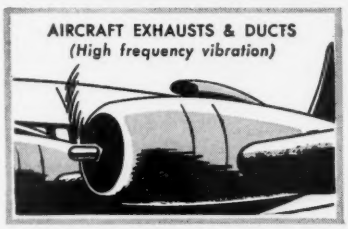

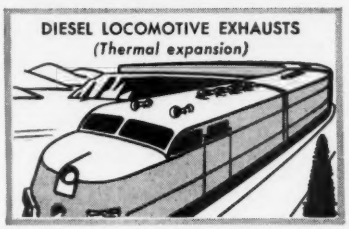

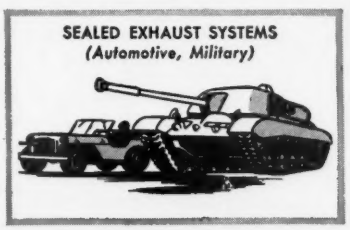

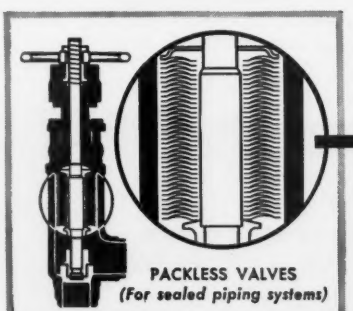

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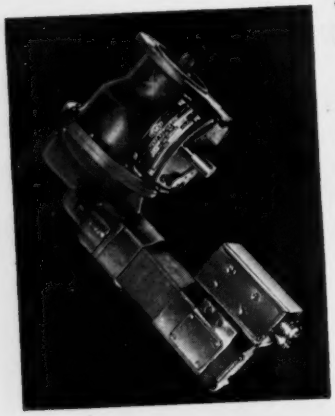

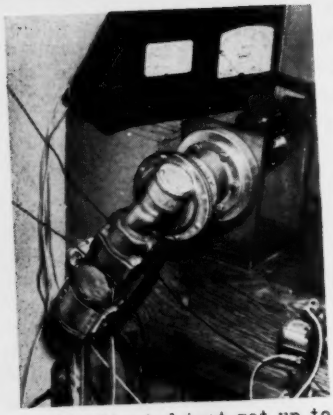

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Book Notes

AERODYNAMICS

The Science of Flight. O. G. Sutton. Harmondsworth, Middlesex, Penguin Books; Baltimore, Md., Allen Lane, Inc., 1949. 208 pp., illus. 1s. 6d.

Professor Sutton's admirable book is intended for the layman and covers the theoretical aspects of flying. Aircraft design and the actual technique of flying are not discussed. The Beginnings of Aerodynamics, The Problem of the Resistance of the Air (2 chapters), The Theory of the Wing, Stability in Flight, The Aerodynamical Problems of High-Speed Flight, The Ultimate Flying Machine, and The Tools of Aerodynamics are the topics discussed. The reader is required to know the elements of algebraic notation only. The author, who is Bashforth Professor of Mathematical Physics at the Military College of Science in Shrivenham, has done an excellent job of explaining complex ideas clearly, from the spear of the primitive hunter to the supersonic airplane and the giant step rocket.

AIRPLANE DESIGN

Airplane Design Manual. Frederick K. Teichmann. 3rd Ed. New York, Pitman Publishing Corporation, 1950. 382 pp., figs. $7.50.

In this new edition of a textbook last revised in 1942, new chapters have been added on airfoil selection and materials of construction, and revisions and additions have been made in other chapters. The chapter on Instruments and Equipment, for example, includes new material on safety equipment, de-icing and anti-icing, and the chapter on power plants has been considerably enlarged to include the new types of gas-turbine and rocket engines. Appendix material has been revised and now includes extensive weight data, design data on typical American airplanes (Boeing B-17, Douglas A-20, Fleetwings BT-12, Lockheed P-38, North American P-51, and Republic Seabee), airplane data, and materials design data. Professor Teichmann is Chairman of the Department of Aeronautical Engineering, New York University.

AIRPORTS

Snow Melting. T. Napier Adlam. New York, The Industrial Press, 1950. 224 pp., illus., figs. $4.50.

The design, installation, and control of systems for melting snow by underground hot-water coils are discussed, with snow-fall data, test data, heat calculations, antifreeze data, and data on friction and expansion within the system included. Specific applications, including airport runways, are discussed in the later chapters. The costs of installation and operation of snow melting systems are discussed in a separate chapter.

ATOMIC ENERGY

Sourcebook on Atomic Energy. Samuel Glasstone. New York, D. Van Nostrand Company, Inc., 1950. 546 pp., figs. $2.90.

This work was undertaken at the request of the American Textbook Publishers Institute to the U.S. Atomic Energy Commission for a comprehensive sourcebook for the use of textbook authors and editors. Dr. Glasstone presents a thorough survey from the earliest theories of the atom and its structure to the latest cyclotrons, betatrons, atomic piles, man-made new elements, and the uses of isotopes. A large amount of material is made available here in readable, but not oversimplified form, and the book should be indispensable as a reference for persons interested in nuclear physics and its applications. Name and subject indexes are provided.

Industrial and Safety Problems of Nuclear Technology. Morris H. Shamos and Sidney G. Roth. New York, Harper & Brothers, 1950. 368 pp., illus. $4.00.

The eighteen papers in this volume were presented in a three-day conference held in January, 1950, by the U.S. Atomic Energy Commission and New York University's Division of General Education. Part I includes papers on United States Atomic Energy Commission Activities; Part II, Radiochemistry and Isotopes; Part III, The Radiochemical Laboratory; and Part IV, Hazards, Safety, and Insurance. The appendix includes panel discussions on Technological Problems and on the Impact of Atomic Energy upon Insurance and Safety.

AVIATION MEDICINE

Research on the Measurement of Human Performance. N. H. Mackworth. (Gt. Brit., Medical Research Council, Special Report Series No. 268.) London, H. M. Stationery Office; New York, British Information Services, 1950. 156 pp., diagrs. $1.00.

The procedures and results are reported of tests on groups of Royal Air Force cadets, naval ratings, and ground troops for visual and auditory vigilance, and on the effects of environmental stress. Environmental stress included tests for the effects of nonlethal war gases (tear gases and arsenical smoke) and the effects of atmospheric temperatures up to 92°F., with high humidity, on the performance of the subjects in a pull test, a test with a heavy pursuitometer, and tests on telegraphy reception and coding.

ELECTRONICS

TV and Other Receiving Antennas (Theory and Practice). Arnold B. Bailey. New York, John F. Rider Publisher, Inc., 1950. 595 pp., figs. $6.00.

This book opens with a review of definitions and terminology, proceeding into an analysis of the television signal, conditions determining signal levels at the receiver, and problems of propagation as they relate to operations up to 1,000 mc. Antenna theory proper and its practical applications are discussed in the last seven chapters. Data sheets on approximately 50 different basic types of antennas are provided, and advantages and disadvantages of each basic type are discussed, with recommendations on its use. The author, a consulting engineer, aims to provide usable information based on his experience and has not stressed mathematical theory or proof. Bibliographies are included at the ends of chapters.

EQUIPMENT

HYDRAULIC

Positive-Displacement Pumps and Fluid Motors. Warren E. Wilson. New York, Pitman Publishing Corporation, 1950. 250 pp., figs. $7.50.

This textbook is intended for graduate engineers entering the field of hydraulic pumps, motors, and power-transmission systems and as a summary of available information for the experienced man. The first five chapters form an introduction, covering elementary concepts, Deviations from Ideal Performance, Classification of Pumps and Motors, Characteristics and Applications of Positive-Displacement Units, and Elementary Performance Calculations. The final six chapters, designed for the practicing engineer, develop a more complete theory of operation and apply it to methods of test data analysis and design. The operation of hydraulic clutches and transmissions is discussed in the two final chapters. A bibliography of about 500 items, from 1929 through 1949, is included. The author is President of the South Dakota School of Mines and Technology.

MACHINE ELEMENTS

Bibliography on Non-Metallic Bearings. (Engineering Societies Library Bibliography No. 6.) New York, Engineering Societies Library, 1950. 13 pp. $2.00.

This is an annotated list of 101 selected references, including 93 articles and 8 books, on plastic, wood, nylon, rubber, and other nonmetallic bearings, covering their manufacture, design, properties, wear, lubrication, performance, testing, and application. The period covered is 1939 to early 1950. Foreign literature is included.

MANAGEMENT & FINANCE

Joint Industry-Faculty Conference on Engineering Management, February 26, 1947 and April 27, 1948. Baton Rouge, La., Louisiana State University, 1947–1948. 2 Vols. 40, 50 pp.

MATERIALS

METALS & ALLOYS

Metals and Alloys. Technical Staff of Metal Industry. Brooklyn, N.Y., Chemical Publishing Company, Inc., 1950. 214 pp. $5.00.

The greater part of this book (pp. 14–214) consists of a table of Percentage Compositions of Non-Ferrous Alloys, giving percentages of aluminum, chromium, copper, iron, lead, magnesium, nickel, tin, and zinc, with a separate column for miscellaneous elements. About 4,600 compositions are listed, an increase of about 900 over the number in the previous edition in 1941. The alloys included have not more than 50 per cent iron. They are listed by their proprietary names (Duralumin, Dowmetal, etc.), and unnamed alloys are grouped according to commonly used (British) names. Where they are grouped according to the names of their constituents, the major constituent is the key word. Each alloy appears in only one place in the list.

The Selection and Hardening of Tool Steels. Lawrence H. Seabright. New York, McGraw-Hill Book Company, Inc., 1950. 263 pp., figs. $5.00.

A systematic guide is presented for the selection of water-hardening, high-speed, and hot-work tool steels, arranged according to their toughness and wear resistance, in twelve main groups and 40 subgroups. Designed for tool designers, metallurgists, heat-treaters, and other tool steel users, it presents 960 analyses, covering all standard tool steels produced in the United States and Canada. The data are presented in table form in the introduction, and the greater part of the book covers details of heat treating, tempering, and variations in composition and their effect on tool steel properties. The author is a Chemical and Metallurgical Engineer with the Vulcan Stamping and Manufacturing Company.

MILITARY AVIATION

A World Airlift, the United Nations Air Police Patrol. Elvira K. Fradkin. New York, Funk & Wagnalls Company, 1950. 216 pp., illus. $2.85.

A plan is outlined for the establishment of a United Nations Air Police Patrol, operating within the U.N. framework under the Military Staff Committee and the Security Council. Preparatory steps toward this already taken by both East and West blocs of nations are outlined, and details of the size, functions, operation, and cost of the proposed patrol are discussed.

United States Civil Defense. U.S. National Security Resources Board. Washington, U.S. Govt. Printing Office, 1950. 162 pp., diagrs. $0.25.

A detailed plan is outlined for the organization of civil defense, including steps of the federal, state, and local governments in the establishment of health, fire, rescue, and protective services. Suggested organization charts, a basic civil defense law, and a model State Civil Defense Act are included.

How to Survive an Atomic Bomb. Richard Gerstell. Washington 6, D.C., Combat Forces Press; New York, Rinehart & Company, Inc., 1950. 150 pp., illus. $0.35.

Easy-to-read facts are presented on the effects of an atom bomb and what to do in the vicinity of its explosion. The text is in the form of questions

and detailed answers. Dr. Gerstell is Consultant to the Civil Defense Office, National Security Resources Board, and was Senior Radiological Safety Monitor for Initial Boarding Teams, Operation Crossroads (Bikini).

PRODUCTION

Aluminum and Magnesium Design and Fabrication. R. Burt Schulze. New York, McGraw-Hill Book Company, Inc., 1949. 589 pp., figs. $7.50.

The author's aim is to provide a source of information for the designer, engineer, and manufacturer on light-metal design and fabrication, with particular reference to recent developments reported in scattered sources. The differences between machining, theory of forming, stress analysis, and forming of aluminum, magnesium, and other materials are treated in detail. Introductory chapters on Characteristics and Forms of the Materials, Material Properties and Theory of Forming, and Machining Operations are followed by a chapter on Experimental-Production Forming Methods and six chapters on Limited-Production Forming Methods. These discuss the router, shaper, press brake, hydraulic press, mechanical press, drop hammer, contour roll former, and stretch presses, and there is an extensive chapter on the rubber hydraulic press. Assembly procedure and tooling, mechanical fastenings, and welded and bonded fastenings are discussed in the next three chapters. The book ends with a detailed discussion of cost analysis of production in light metals and two chapters on General Design Principles and Design Applications. The author is Supervisor of Manufacturing Research, The Glenn L. Martin Company.

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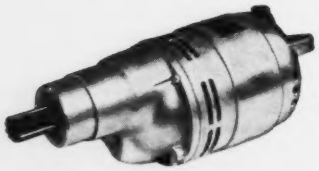

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REFERENCE LITERATURE

YEARBOOKS

The Ships and Aircraft of the United States Fleet. James C. Fahey. 6th Ed. Washington 18, D.C., Ships and Aircraft, 1950. 48 pp., illus. $2.00.

In this new edition of a standard reference book, the U.S. Navy is described in quick reference form, covering all ships in the Navy Register as of January 1, 1950. Aircraft carriers, aircraft repair ships, aviation supply ships, and aircraft cargo ships are included. There are eight pages on Navy aircraft, covering data on over 50 current models.

REFRIGERATION

Refrigeration Engineering. H. J. Macintire and F. W. Hutchinson. 2nd Ed. New York, John Wiley & Sons, Inc., 1950. 610 pp., figs. $6.50.

In this new edition of a textbook originally published in 1937, new material includes two chapters on the analysis of transient phenomena, over 30 graphic solutions giving direct-reading values of the film coefficient of heat transfer for commonly used refrigerants, and the heat-pump thermodynamic-cycle analysis from the standpoint of transient heat flow problems. There is a new chapter on the influence of radiation effects in the determination of equilibrium cold-storage temperature, including a detailed design procedure for comfort-panel cooling systems. The chapters on psychometrics and absorption cycles have been left substantially unchanged. The late Professor Macintire was Professor of Refrigeration at the University of Illinois; Professor Hutchinson teaches mechanical engineering at the University of California.

RESEARCH FACILITIES

The Art of Scientific Investigation. W. I. B. Beveridge. New York, W. W. Norton & Company, Inc., 1950. 171 pp., illus. $3.00.

The author's purpose is to present an introduction to the knowledge available on the practice and mental skills of scientific investigation. Considering research as an art, he discusses it from the standpoint of its practice and psychology, rather than the philosophical point of view, under such topics as preparation, experimentation, chance, hypothesis, imagination, intuition, reason, observations, difficulties, and strategy. Examples are taken largely from author's experience in research in infectious diseases, though he states that much of the book is applicable to any branch of science. The author is Professor of Animal Pathology and Director of the Institute of Animal Pathology at Cambridge University. A bibliography of 108 items is included.

SCIENCES, GENERAL

ASTRONOMY

A Century of Astronomy. Angus Armitage. London, Sampson Low; New York, Macdonald & Company (Publishers) Ltd., 1950. 256 pp., illus., diagrs. $2.20.

The author's purpose is to provide the general reader with a history of the last 100 years, showing the interconnection of contemporary physical theory and technique with the role of astrophysics in the development of astronomy. The established geometric and gravitational branches of the science, though their value as foundations is stated, are less emphasized. Accounts of persons who have made contributions are included. Chapters deal with spectroscopy, the moon, the sun and the solar system, the stars, and the galaxy and beyond. There is a list of books for the general reader. The author is Lecturer in the Department of History and Philosophy of Science in University College, London.

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CHEMISTRY

Advances in Radiochemistry and in the Methods of Producing Radioelements by Neutron Radiation. Engelbert Broda. London and New York, Cambridge University Press, 1950. 152 pp. $2.75.

This monograph deals with advances since about 1928, including the production as well as the chemical properties of radioelements. Applied radiochemistry, where radioelements are not the objects but the tools of research, is omitted, although applications to metallurgy, friction, and to industry generally are referred to. Radiation chemistry is also omitted. Extensive bibliographies are provided, in addition to author and subject indexes. Dr. Broda is Dozent in Physical Chemistry at the University of Vienna.

MATHEMATICS

Ordinary Non-Linear Differential Equations in Engineering and Physical Sciences. N. W. McLachlan. London and New York, Oxford University Press, 1950. 201 pp., figs. $4.25.

The author's purpose is to provide a practical introduction for engineers and physicists to ordinary nonlinear differential equations, with representative applications in such typical fields as acoustics, aerodynamics, stress analysis, plasticity, and kinematics. After a general introduction, the following chapters are taken up: Equations Readily Integrable; Equations Integrable by Elliptic Integrals and Functions; Equations Having Periodic Solutions; Method of Slowly Varying Amplitude and Phase; The Equivalent Linear Equation; Equations Having Periodic Coefficients; and Graphical and Numerical Solutions. There are 211 references in the bibliography, referring to justifications of the methods used and to further applications in nonlinear mechanics.

Operational Calculus, Based on the Two-Sided Laplace Integral. Balth. Van der Pol and H. Bremmer. Cambridge and New York, Cambridge University Press, 1950. 415 pp., figs. $10.

This book was developed from two series of lectures given by the senior author at the Technische Hogeschool in Delft and at the Philips Research Laboratories in Eindhoven, beginning in 1938. The book is intended for application of the modern form of operational calculus to mathematical, physical, and technical problems. Though worked-out examples are liberally included and the subject matter is given in a form suitable for application simply to practical problems, the treatment is rigorous and is more advanced than is usual in this type of book. The theory is based on the two-sided Laplace integral, leading to early introduction of the Heaviside unit function $U(t)$, and the Dirac delta or impulse function. Operational rules (the "grammar" of operational calculus), and operational relations (the "dictionary") useful in translating the language of t into that of p, or the reverse, are given in appendixes. Dr. Van der Pol is Director of the International Radio Consultative Committee in Geneva, and Dr. Bremmer is associated with the Philips Research Laboratories.

High-Speed Computing Devices. By the Staff of Engineering Research Associates, Inc. New York, McGraw-Hill Book Company, Inc., 1950. 451 pp. $6.50.

This is primarily a discussion of the mechanical devices and electrical circuits that can be incorporated into computing machines. Though a detailed comparison of various machines is not attempted, descriptions of a few American computers are included as examples. The first part deals with the Basic Elements of Machine Computation, including counters as elementary components, switches and gates, a functional approach to computer design, arithmetic systems, and numerical analysis. In the second part, computing systems are discussed, including desk calculators, punched-card computing systems, large-scale digital computing systems, analog computing systems, and the form of a digital computer. Physical components and methods are covered in the final chapters, including arithmetic elements,

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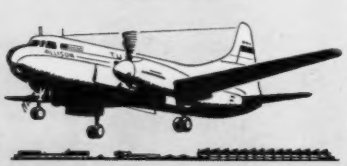

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transfer mediums, data-conversion equipment, special techniques and equipment, and the choice of equipment. More than 625 references are given in the excellent bibliographies at the ends of chapters.

Experimental Designs. William G. Cochran and Gertrude M. Cox. New York, John Wiley & Sons, Inc., 1950. 454 pp. $5.75.

In this handbook, directed at the experimenter, statistical methods that have proved to be useful are described in detail, with accompanying plans and an account of the experimental situations for which each design is most suitable. While a brief review is given of the basic theory, the reader is required to have knowledge of the principles of analysis of variance and of the computational methods involved. References to books and papers accompany each chapter, and there is a classified list of more than 100 references at the end; authors are indexed separately. Professor Cochran teaches biostatistics at the Johns Hopkins University, and Dr. Cox is Director of the Institute of Statistics at the University of North Carolina.

Lectures on Classical Differential Geometry. Dirk J. Struik. Cambridge, Mass., Addison-Wesley Press, Inc., 1950. 221 pp., diagrs. $6.00.

This textbook was developed by Professor Struik from a course in differential geometry for upper classmen and graduate students at the Massachusetts Institute of Technology. Fundamental conceptions of the theory of curves and surfaces are presented and applied to numerous examples. A bibliography of books in English, French, German, and Italian is included. The author gives attention to historical and biographic material and indicates sources consistently.

First Course in Probability and Statistics. J. Neyman. New York, Henry Holt and Company, 1950. 350 pp. $3.50.

This textbook is adaptable for both the single course for general purposes in mathematical statistics and the course for specialists requiring it as a tool in specific fields. The first four sections (250 pages) cover the introduction, probability, probabilistic problems in genetics, and random variables and frequency distributions. The final and principal section (100 pages) deals with the theory of testing statistical hypotheses, including a number of examples. An index of names refers to the numerous bibliographic footnotes, and there is an index of subjects. The author is with the Statistical Laboratory of the University of California.

Table of the Bessel Functions $Y_0(z)$ and $Y_1(z)$ for Complex Arguments. Prepared by the Computation Laboratory, National Bureau of Standards. New York, Columbia University Press, 1950. 427 pp. $7.50.

The functions $Y_0(z)$ and $Y_1(z)$ are tabulated for complex arguments defined in polar coordinates, continuing the tabulation of functions $J_0(z)$ and $J_1(z)$ in an earlier volume (1947). Along each of the rays $\varphi = 0°, 5°, \ldots, 90°$, ten-place values of the real and imaginary parts of $Y_0(z)$ and $Y_1(z)$ are given for values of $|z|$ ranging from 0 to 10 at intervals of 0.01. Certain auxiliary functions are tabulated for values of $|z|$ ranging from 0 to 0.50 at intervals of 0.01. Applications to the solution of boundary-value problems in the theory of potential, heat conduction, and wave motion, the method of compilation, and interpolation are discussed in the introduction by Dr. Arnold N. Lowan of the Computation Laboratory.

Contributions to Fourier Analysis. (Annals of Mathematics Studies, No. 25.) Princeton, N.J., Princeton University Press, 1950. 188 pp. $3.00.

Contents: Localization of Best Approximation, S. Bochner. Dirichlet Problem for Domains Bounded by Spheres, S. Bochner. The Fréchet Variation and Pringsheim Convergence of Double Fourier Series, M. Morse and W. Transue. Norms of Distribution Functions Associated with Bilinear Functionals, M. Morse and W. Transue. Note on the Boundary Values of Functions of Several Complex Variables, A. P. Calderón and A. Zygmund. On the Theorem of Hausdorff-

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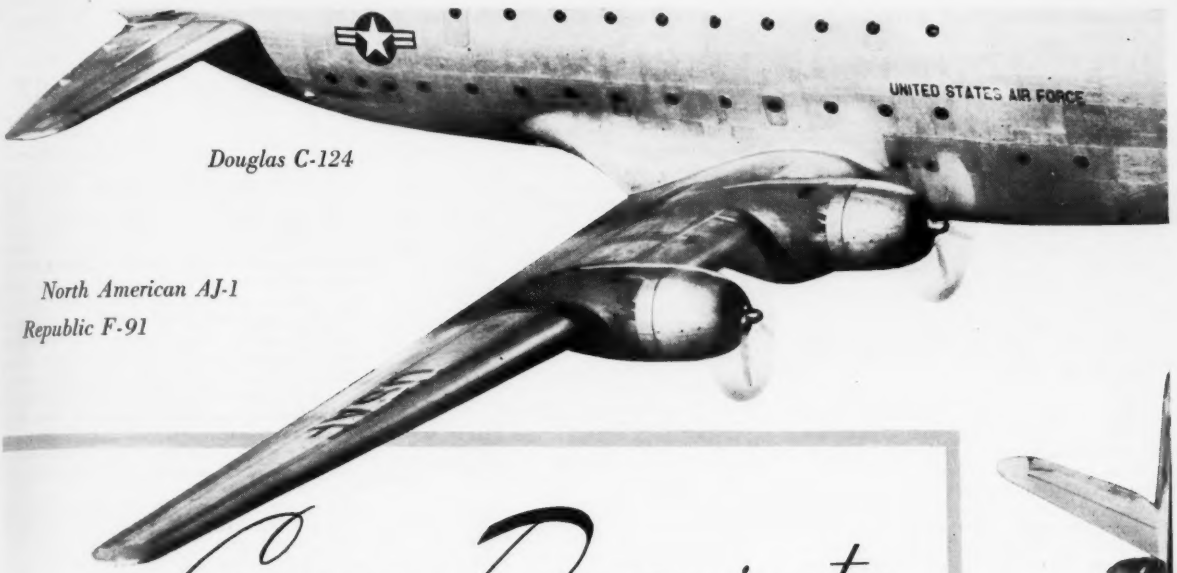

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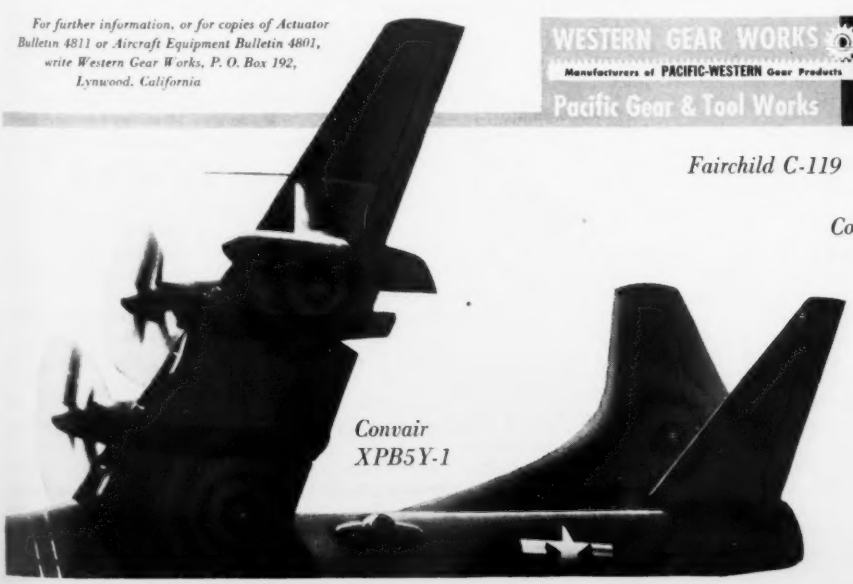

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Young and Its Extensions, A. P. Calderón and A. Zygmund.

An Introduction to Vector Analysis for Physicists and Engineers. B. Hague. London, Methuen & Company, Ltd.; New York, John Wiley & Sons, Inc., 1950. 122 pp., diagrs. $1.25.

This book was originally published in 1939 and revised in 1944 and 1946. It is written from the physical standpoint, with geometric and exclusively mathematical questions limited to essentials. The elementary properties of tensors and dyadics in their relation to vectors are discussed briefly in a final chapter. Reference to more detailed books is made in a bibliographic note. The author is Professor of Electrical Engineering at the University of Glasgow.

Linear Differential Equations. William Vernon Lovitt. New York, Dover Publications, Inc., 1950. 253 pp. $3.50.

This is a welcome reprint of Professor Lovitt's excellent introduction to linear integral equations, originally published in 1924. The general theory of linear integral equations is presented, with applications to differential equations, calculus of variations, and such aspects of mathematical physics as Neumann's problem, Dirichlet's problem, and certain vibration problems leading to differential equations with boundary conditions. The discussion is confined to linear equations in which a single integration occurs.

OPTICS

Fundamentals of Optics. Francis A. Jenkins and Harvey E. White. 2nd Ed. New York, McGraw-Hill Book Company, Inc., 1950. 647 pp., illus., diagrs. $7.00.

In this new edition of a textbook originally on physical optics, published in 1937, a section of ten chapters on geometrical optics has been added at the beginning, presenting the subject at a level somewhat beyond the elementary. A final chapter is added on the quantum behavior of light. The 19 chapters of the section on physical optics have been revised to include new experimental material, new standard letter symbols, and certain classical material recommended by readers. The authors are Professors of Physics at the University of California.

PHYSICS

Kinetic Theory of Gases. Martin Knudsen. London, Methuen & Company, Ltd.; New York, John Wiley & Sons, Inc., 1950. 64 pp., diagrs. $1.25.

Originally published in 1934, this book is based on lectures given by Professor Knudsen at the University of London in 1933. The foundations of the theory are discussed in the first two chapters, and the remaining nine chapters deal with experimental investigations of the author, particularly in the domain of the large mean free path of gas molecules. The author is Professor of Physics at the University of Copenhagen.

Wave Motion and Sound. R. W. B. Stephens and A. E. Bate. London, Edward Arnold & Company; New York, Longmans, Green & Company, 1950. 448 pp., illus., diagrs. $9.00.

The authors' purpose is to provide a textbook of sound between the elementary text and the advanced treatise, relating the theory of vibrations to analogous problems in electricity, light, and other branches of physics. The more mathematical theory is largely contained in 30 appendixes (pages 355–432). The coverage of the volume is wide, ranging from early chapters on periodic motion, wave propagation, and transverse vibrations, to final chapters on analogies and ultrasonics. The range of sciences in which applications are made is also wide, and aeronautical examples are numerous. Bibliographies accompany each chapter. The authors are Senior Lecturers in Physics respectively at the Imperial College of Science and Technology and Sir John Cass College in London.

Applications of Interferometry. W. Ewart Williams. London, Methuen & Company, Ltd.; New York, John Wiley & Sons, Inc., 1950. 104 pp., diagrs. $1.25.

Originally published in 1930, this book deals with interferometer arrangements involving point or line sources (division of wave front) and involving a division of amplitude. The final chapters cover simultaneous division of amplitude and of wave-front and interference effects with more than two beams. There is a separate chapter on the Michelson stellar interferometer and its applications. Bibliographies are included at the ends of chapters.

Negative Ions. H. S. W. Massey. 2nd Ed. London and New York, Cambridge University Press, 1950. 136 pp., diagrs. $2.50.

In this new edition of a monograph first published in 1937, new advances are described in the applications of negative ions to the interpretation of terrestrial, solar, and stellar atmospheric phenomena, including the role of the negative ion of hydrogen in determining the spectral distribution of solar radiation. A bibliography of about 150 references has been added, keyed to pages in the text.

Aeronautical Reviews (Continued from page 81)

high Mach Numbers are obtained by firing models at high speed into a supersonic air stream.

Dual Tunnel Teams Instruction, Research. *Aviation Week*, Vol. 53, No. 21, November 20, 1950, pp. 29, 30, 33, 36, illus.

Wind tunnel developed by the N.A.C.A. and O.N.R. serves as a facility for instruction or for basic research in high-speed aerodynamics. The unit consists of two tunnels and their auxiliary equipment. For $M = 0.4$–1.4, an induction tunnel with a 4- by 16-in. test section is used. A blowdown (compression system) tunnel with a test section of 4 by 4 in. is used for Mach Numbers up to 4.0. Test run durations of 400 sec. can be made at half-hour intervals; the length of the run depends on the stagnation pressures maintained.

Martin M-6-C Balance. Werner F. Hess and Lewis G. Cooper. *The Martin Star*, Vol. 9, No. 11, November, 1950, pp. 14, 15, 19, illus.

A wind-tunnel balance developed by The Glenn L. Martin Co. Values for the three forces and three moments can be read directly from dials in the control panel; all six components are recorded simultaneously. The balance, which weighs less than 3 lbs., is of cylindrical shape and is less than 10-in. long. It is installed inside the model being tested.

A Balsa-Dust Technique for Air-Flow Visualization and Its Application to Flow Through Model Helicopter Rotors in Static Thrust. Marion K. Taylor. *U.S., N.A.C.A., Technical Note No. 2220*, November, 1950. 47 pp., illus.

Fluid Flow and Heat Transfer at Low Pressures and Temperatures: Progress Report on the Design of a Preliminary Optical System for the Oxygen Absorption Flow Visualization Method. R. A. Evans. *California, University, Institute of Engineering Research, Special Technical Report No. HE-150-61*, June 7, 1950. 20 pp., illus. 6 references.

Fluid Flow and Heat Transfer at Low Pressures and Temperatures: Preliminary Report on an Electrical Discharge Method for Flow Visualization in a Low Density Supersonic Wind Tunnel. E. D. Kane. *California, University, Engineering Research Projects, Technical Report No. HE-150-51*, February 23, 1949. 9 pp., illus. 8 references. Investigation of the nitrogen afterglow system.

Fluid Flow and Heat Transfer at Low Pressures and Temperatures: Progress Report on Design and Operation of a Source of 1470 Å Radiation. R. A. Evans. *California, University, Engineering Research Projects, Technical Report No. HE-150-60* April 29, 1950. 19 pp., illus. 7 references.

Design of a method of flow visualization for operation at test-section pressures as low as 0.01 mm. Hg, which is based on the ability of O_2 to absorb radiation of 1470 Å wave length.

Transformation of Certain Series Occurring in Aerodynamic Interference Calculations. F. W. J. Olver. **Note on the Preceding Paper.** G. E. H. Reuter. *Quarterly Journal of Mechanics and Applied Mathematics*, Vol. 2, Part 4, December, 1949, pp. 452–459, illus. 5 references.

Stability Derivatives; The Use of Strain Gauge Balances in the Measurement of Velocity and Control Derivatives. P. T. Fink. (*Australia, Council for Scientific and Industrial Research, Division of Aeronautics, Report No. A.58*, May, 1949.) *Australia, Department of Supply, Aeronautical Research Consultative Committee, Report No. ACA-47*, August, 1949. 20 pp., illus. 10 references.

An Electronic Speed Control for the Towing Carriage of a Ship-Model Testing Tank (National Physical Laboratory). R. H. Tizard and B. G. V. Harrington. *Institution of Electrical Engineers, Proceedings, Part 2, Power Engineering*, Vol. 97, No. 59, October, 1950, pp. 651–662, illus. 8 references.

Design and operation of a simple closed-loop automatic control system for maintaining constant speed of the carriage relative to land. The system is a proportional-control one; the carriage speed is directly proportional to the deviation. Circuit diagrams of the system are included.

Development of Wax Ship Model Manufacturing at the David Taylor Model Basin. R. B. Couch. *U.S., Navy Department, David W. Taylor Model Basin, Report No. 728*, August, 1950. 22 pp., illus.

Current Projects in Aerodynamics Laboratory, Aircraft and Allied Instruments Laboratory, Engine Laboratory, Flight Research Section, Fuels and Lubricants Laboratory, Hydraulics Laboratory, Low Temperature Laboratory, Structures Laboratory, and Supersonics and Gas Dynamics Laboratory. *Canada, National Research Council, Aeronautical Laboratories, Quarterly Bulletin, Report No. ME 1950 (3)*, July 1–September 30, 1950, pp. 12–31, illus.

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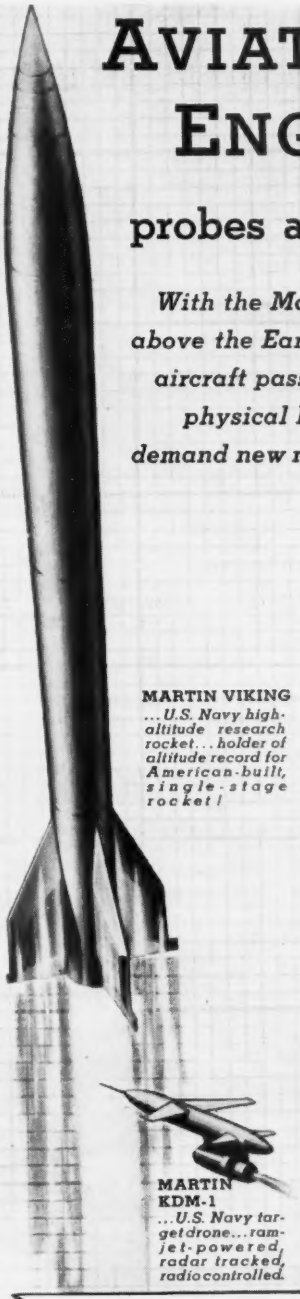

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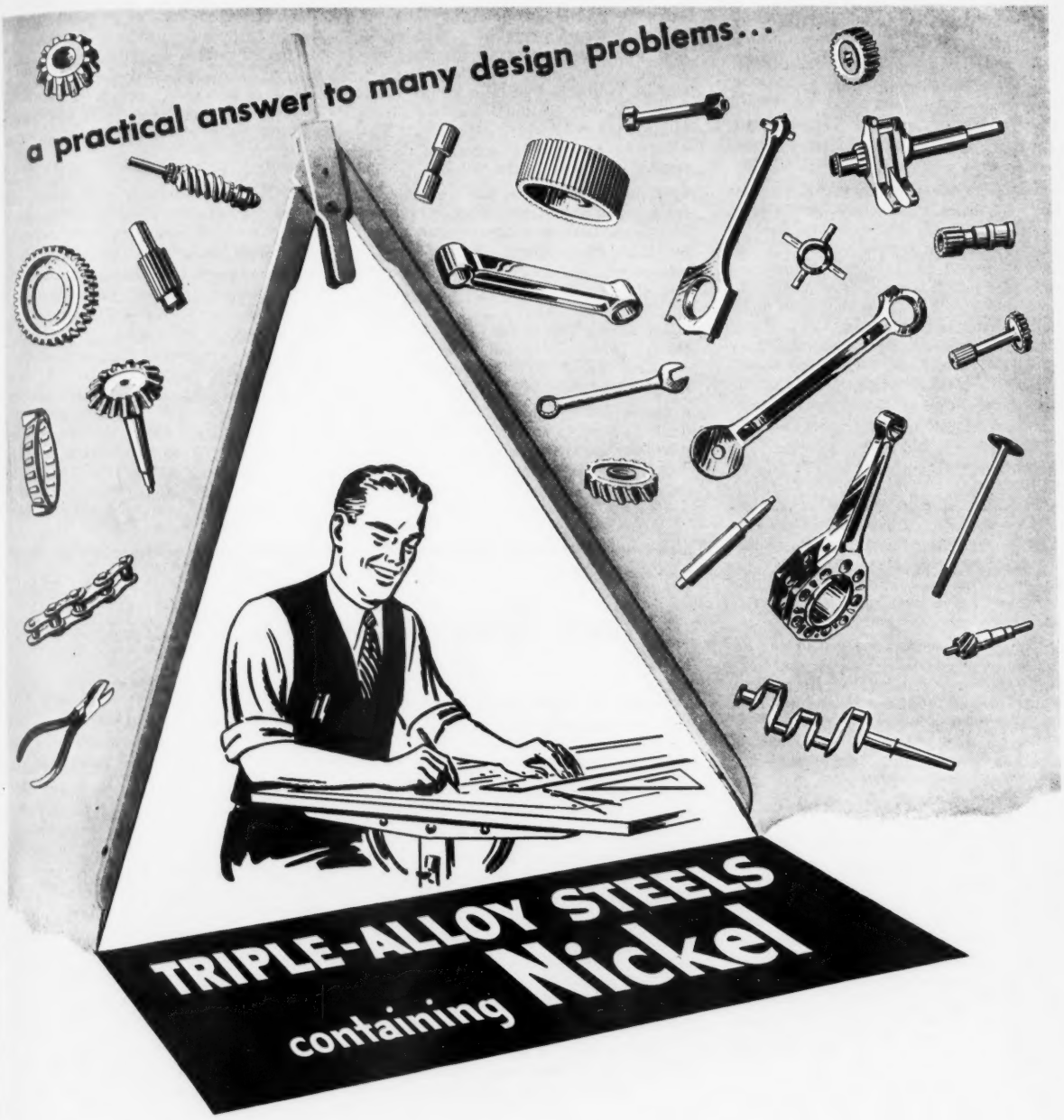

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Because of their many advantages, these triple-alloy steels warrant your careful consideration when planning new or improved designs. We shall be glad to furnish counsel and data upon request.

THE INTERNATIONAL NICKEL COMPANY, INC. 67 Wall Street New York 5, N. Y.

Corporate Member News

(*Continued from page 17*)

high by 10½ in. deep and weighs 24 lbs. The receiver is tunable over the 108–127-mc. frequency range.

• **North American Aviation, Inc.** . . . Air bearings that are lubricated by a film of air 1/1,000 in. in thickness are said to have no starting friction. It is claimed that the use of air bearings in components of guided missiles causes those parts to be friction-free, the bearings sliding on molecules of air in the bearing race. Air is forced into the bearing race through tiny capillaries drilled to 1/3,000 in. in diameter . . . On-schedule delivery of the last F-86A Sabre jet fighter was made to the U.S.A.F. Production was meanwhile under way on two later versions of the airplane—the F-86E super-controlled jet fighter and the F-86D jet interceptor.

• **Pan American World Airways, Inc.** . . . A wooden mock-up of a Convair-type Clipper that was used to indoctrinate flight crews was given to the Dade County, Fla., school system. It will be used in connection with the aircraft mechanics training program.

• **The Parker Appliance Company** . . . A recently published 58-page *Aircraft Fittings Catalog 701*, available on request, illustrates and tabulates dimensional data for a complete size range of AN-specification tube, hose, pipe, universal, bulkhead, and swivel fittings. A special section is devoted to the complete line of Parker tube cutting, flaring and bending tools, and accessory items.

• **Pratt & Whitney Aircraft Division, United Aircraft Corporation** . . . A faster, more efficient, and cheaper method of producing compressor-blade masters for jet engines has been developed. The new method uses an electronic contour follower that utilizes a special electronic machine automatically linked to a standard jig borer. A cross-sectional metal drawing of the airfoil contour desired at any particular point in the master blade is fed into the electronic machine. There, a photoelectric eye scans the drawing and feeds the information to the jig borer that faithfully reproduces the airfoil contour in the metal blank from which the blade master is made. This process has cut the cost of a single compressor-blade master from over $4,000 to $100 and reduced the time required from 4 to 6 months to 3 working days.

• **A. V. Roe Canada Limited** . . . A porous wick that will absorb any moisture collecting in the cabin of a pressurized aircraft and transmit it to the exterior of the aircraft for evaporation has been developed. The wick has a short stem that terminates in an absorption pad at one end and an evaporating pad at the other. The stem, itself, fits snugly in a drain hole . . . The CF-100 was flown last November to Wright-Patterson Air Force Base, Dayton, Ohio, for the purpose of enabling the staff officers of the U.S. Air Force's Air Materiel Command to become acquainted with the CF-100's handling characteristics and performance.

• **Sperry Gyroscope Company, Division of The Sperry Corporation** . . . A Modifications Center with comprehensive machining, assembling, and test facilities will be established at MacArthur Field, L.I., N.Y., in a portion formerly occupied by Lockheed Aircraft Services, Inc., which is moving its activities to the New York International Airport.

• **Thompson Products, Inc.** . . . An exclusive license agreement has been entered into with Designers for Industry, Inc., by which Thompson has taken over development, manufacture, sales, and service of coaxial switches. Accordingly, an Electronics Division has been established at the Thompson Cleveland main plant. Initial operations are a joint responsibility of Staff Development and the Special Products Division.

• **Union Carbide and Carbon Corporation** . . . A lightweight, air-cooled Heliarc torch for inert gas-shielded arc welding was announced by Union's Linde Air Products Company. The torch, which has a two-position welding head, has a maximum current capacity for continuous duty of 75 amp. It is designed for welding thin-gage materials. It can be used with either straight-polarity direct current or high-frequency stabilized alternating current.

• **Vickers, Inc.** . . . A new reversing or two-speed Magneclutch has been announced by the Vickers Electric Division. It includes two driving members and only one driven member. The two driving members rotate continuously in opposite directions, and a simple reversing drive, controlled by energizing the proper excitation coil, is achieved.

• **Wright Aeronautical Corporation, Curtiss-Wright Corporation** . . . The nine Super Constellations, recently ordered from Lockheed Aircraft Corporation by KLM, the Royal Dutch Airline, will be powered with Wright compound engines, the Turbo-Cyclone 18's.

Meet Your Section Chairmen

Captain George J. Higgins

Baltimore Section

Captain George Judson Higgins, U.S.N.R., began his naval career back in January, 1917, when, as a University of Michigan Sophomore in Naval Architecture he enlisted in the Michigan Naval Militia. Called to active duty on April 6, 1917, he enrolled in the National Naval Volunteers in May of that year, and the following July he was transferred to Naval Aviation with a rating of MM1c (Gunner Engineer). He remained in the Naval Reserve Force until the termination of his enrollment in 1920, at which time he returned to his interrupted studies at the University of Michigan. This time, however, he majored in aeronautical engineering and was graduated in February, 1923, with a B.S. degree in Aeronautical Engineering. He played the flute and piccolo in the Michigan Band during the years, 1920–1922, and to this day he continues his flute playing, using it as a form of relaxation.

From 1923–1928, Captain Higgins was affiliated with the N.A.C.A. at Langley Field, Va. Assigned to the Variable Density Wind-Tunnel Section, he was at first a Junior Aeronautical Engineer; then an Assistant Aeronautical Engineer; and, finally, an Associate Aeronautical Engineer. He was made Head of that section in 1925 and remained in that capacity until 1928, when he left to join the faculty of the University of Detroit. It was during this period (1925–1928) that he designed the first induction jet high-speed tunnel, which was later developed into one of the first N.A.C.A. transonic tunnels. At Detroit he was an Associate Professor and Director of the Aeronautical Laboratory, and in 1940 he became a full Professor and Director of the Department of Aeronautics. He was the designer of the University of Detroit's 7- by 10-ft. subsonic wind tunnel in 1929.

Obtaining a commission in the U.S. Naval Reserve as a Lieutenant Commander in 1937, Captain Higgins was called to active duty in December, 1941, and was assigned to the U.S. Naval Postgraduate School as Professor of Aeronautics. He was promoted to Commander in 1942 and to Captain in 1945. Although he was released from active duty in 1946, he had remained on at the U.S.N.P.S. as Professor of Aeronautics. He is also Director of the Aeronautical Laboratory there.

Captain Higgins is a great archery enthusiast, having first taken it up in 1925. He has served as President of the Michigan Archers' Association from 1930 through 1933 and has attended the national tournaments in 1930, 1931, 1936, 1947, and 1949. He enjoys hunting squirrels, rabbits, and deer using only the bow and arrow, but he complains that, since the beginning of

World War II, he hasn't had time for hunting. He hopes to find the time soon. Incidentally, he has "quite a few" ribbons and trophies from the various target tournaments.

Captain Higgins has authored many papers, among which are found the "Aerodynamics of an Arrow," "Outline for Use in Writing Technical Reports," and miscellaneous notes on aerodynamics for the U.S.N.P.S.

Born in Ann Arbor, Mich., on July 19, 1897, Captain Higgins was educated in the Ann Arbor grade and high schools. He married Florence Iola Rowe in 1923, and the couple have a 22-year-old son.

W. Andrew Pitman

Texas Section

W. Andrew Pitman, Supervisor of Structures Development at Chance Vought Aircraft Division, United Aircraft Corporation, received his Private Pilot Certificate in 1939 under the Civilian Pilot Training Program. However, his interest in an aeronautical career antedates this period, for he tells us: "In 1936, I decided to study aeronautical engineering as an outgrowth of a desire to learn to fly. My interest in flying led me to want to learn more about airplanes. However, after pursuing the study of engineering, my inclination to mechanics and mathematics made engineering more attractive."

Born in Rehoboth Church, Va., on August 9, 1919, Mr. Pitman attended Wake Forest College and the University of Alabama, graduating from the latter in January, 1940, with a B.S. degree in Aeronautical Engineering. Subsequently, he took a course at Yale University entitled, "Engineering Applications of Advanced Mathematics." He was employed by Taylorcraft Aviation Corporation as Structures Engineer from 1940 to 1941. For the next 3 years, he held a comparable position with Universal Moulded Products Corporation, and in 1944 he was with Chance Vought for a 3-month period before being commissioned as a U.S. Naval Ensign. During his 2 years in the Navy, he was attached to the Bureau of Aeronautics, where he first reviewed contractors' structural design and static test data and later was transferred to experimental structures work. Upon his discharge from the Navy, he returned to Chance Vought, where he has since remained.

In speaking of the nature of his duties, he says: "The unit I supervise is responsible for stress analysis methods and of structural design data on new materials, types of construction, and joining methods. A further function is furnishing structural advice to the other groups in our organization, including assistance to process development engineers when the problem at hand requires more than the usual knowledge of mechanics of materials. I also represent Chance Vought when industry guidance is requested by such agencies as the ANC-5, ANC-17, and ANC-23 Panels."

In reviewing the various episodes of his career, Mr. Pitman writes: "Certainly one of the most interesting episodes has been participating in the reactivation of the Texas Section of the Institute, first as Vice-Chairman and then as Chairman, since the departure of Russell McCrea from the Section in July. Virtually, the entire course of my career has been most interesting, which is the real reason for choosing to enter and continue in the profession. Outstanding in interest, however, is the direction of a program, currently being conducted under contract with the Bureau of Aeronautics, for the evaluation of the formability and structural characteristics of one of the titanium alloys."

Mr. Pitman has "invented a type of adhesive-bonded metal joint which provides improved strength at extreme low temperatures." The patent for this invention has been applied for in Mr. Pitman's name by Chance Vought.

Mr. Pitman and his wife, the former Helen Hobart, are the parents of two young sons, a 3-year-old and an infant born last November. At the moment, Mr. Pitman's chief form of recreation is "entertaining and being entertained" by his sons. As a rule, however, his recreation is derived from his "home workshop" and his "armchair, exploring with the *National Geographic Magazine*."

I.A.S. Sections

Baltimore Section

H. E. Nietsch, *Secretary*

A field trip to inspect the research facilities at the Naval Ordnance Laboratory, White Oak, Silver Spring, Md., constituted the second fall meeting, on November 7. Despite the election-day date, an excellent turnout of over 150 persons, representing aeronautical interests in Baltimore, Washington, Annapolis, and Hagerstown, attended the combined dinner meeting.

Dr. Seeger, Physicist, in charge of N.O.L. Aeronautical Development Programs, initiated the evening program in an after-dinner speech. The subsequent lectures, presented at the Wind Tunnel Laboratory, were given by Dr. G. L. Shue, Chief, Aerodynamics Division, and Dr. H. H. Kurzweg, Chief, Aeroballistics Division, N.O.L.

The Wind Tunnel Laboratory is well furnished with modern equipment, including five supersonic wind tunnels, a huge vacuum Hortonsphere of a diameter exceeding 40 ft., and a 300-ft. long pressurized ballistics range. With this equipment, some of which was moved from Germany after World War II and considerably modernized, working speeds of Mach Number 8 have been attained.

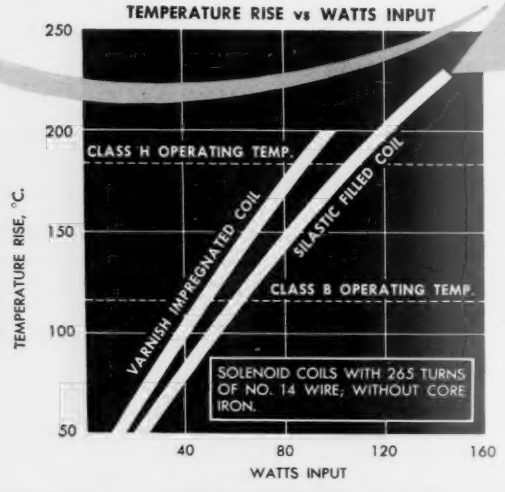
Dr. Shue's lecture related to the equipment and test methods used for basic research in supersonic flow phenomena. The talk was illustrated by (1) slides of the shock-wave formation for several projectiles, (2) slow-motion movies of the turbulent flow during build up to, and reduction from, the supersonic-flow condition, and (3) a demonstration of tunnel operation, in which the shock wave was projected onto a screen by light shining through the test section.

Dr. Kurzweg spoke on the technical problems involved in the development of ballistic devices, with emphasis on the analysis of drag characteristics. Total drag consists of the shock wave, the boundary layer, and the base pressure. Discrepancies between wind-tunnel and free-flight characteristics were found to be attributable to the boundary-layer drag, and these were eliminated by ensuring turbulent flow over the wind-tunnel test specimen through the introduction of external mechanical devices, on the model in the "test rhombus"—the wind-tunnel test section, in which a constant (maximum) Reynolds Number flow condition prevails.

An important problem in ballistics, Dr. Kurzweg stated, relates to the excessive temperatures attained by air friction at high Mach Numbers. On one test the temperature rose, as a parabolic time function, to 1,100°C. within a 60-sec. period.

A third, general problem consists of instrumentation. Dr. Kurzweg explained that measuring devices had to be developed alongside the ballistic research programs. Part of this instrumentation development relates to suitable optical means for determining the pressure distribution field around a projectile.

SILASTIC* the resilient dielectric, stable from -60° to +200°C.



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Thermal stability plus high heat conductivity permit the Silastic coil to operate at 166% of the maximum capacity for an identical organic resin impregnated solenoid. Performance of over 1600 Silastic insulated main and interpole field coils in diesel-electric traction motors is further proof of the extraordinary advantages of Silastic as a dielectric.

In coils of all kinds, Silastic provides resiliency and relatively constant dielectric properties of temperatures ranging from below −60° to above 200°C., maximum resistance to corona, to electrical and mechanical fatigue and to abrasion, oil and outdoor weathering.

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Schlieren and interferometer photographs, which reflect variations in air density, were exhibited, and their respective merits were discussed.

Boston Section

L. J. Nuttall, *Secretary*

The following officers have been elected for the ensuing year: Chairman, William R. Hawthorne, George Westinghouse, Professor of Mechanical Engineering, Massachusetts Institute of Technology; Vice-Chairman, Charles F. Savage, Assistant to the Manager of Engineering, Meter and Instrument Division, General Electric Company; Treasurer, Gustav Kuerti, Harvard University; and Secretary, Leonard J. Nuttall, Development Engineer, General Electric Company.

▶ The year's activities began on November 15 at a meeting held at the Massachusetts Institute of Technology. The new officers for the coming year were introduced, following which R. P. Haviland presented an illustrated talk on the "Bumper Two-Stage Vehicle."

Mr. Haviland's talk covered, as far as Government restrictions would permit, the testing activities that the General Electric Company has been doing on two-stage rockets. The talk was illustrated by slides and movies of actual tests made in New Mexico and Florida and also included a captured German film showing the launching of a V-2 rocket.

Chicago Section

Alfred F. Stott, *Secretary*

The December 5 meeting was held jointly with the S.A.E. in the main ballroom of the Knickerbocker Hotel. Approximately 200 I.A.S. and S.A.E. members and guests were present. A social period, sponsored by the Bendix Aviation Corporation, preceded the dinner. The meeting was called to order at 8:00 p.m. by T. A. Sherger, Chairman of the S.A.E. Chicago Section. Mr. Sherger presented David C. Peterson, of Stewart Warner Corporation, who introduced the guest speaker, Frank Mock, Fuel Feed Engineering, Bendix Aviation Corporation. Mr. Mock spoke on "A Comparison of British and American Jet Engines." He began his talk with a history of jet engines and drew comparisons of fuel consumption and performance between jet and reciprocating engines.

Slides were shown illustrating various types of jet engines, their combustion chambers and afterburners, as well as a series of slides comparing United States, English, and German jets from 1935 to the present time.

Some interesting production problems were discussed. An instructive question-and-answer session followed the talk.

Dayton Section

Major W. A. Barden, *Secretary*

On November 21, approximately 45 members were privileged to hear Col. George W. Goddard, Chief of Air Materiel Command's Photographic Laboratory, give a presentation on "New Developments for Aerial Reconnaissance." Colonel Goddard conducted the group through the Photographic Laboratory Exhibit at Wright-Patterson Air Force Base and explained the many interesting photographs, cameras, and lighting and control equipment used in modern aerial reconnaissance.

Following the inspection of the displays, the group was taken to the auditorium where pictures of many types of photographic equipment were shown, while Colonel Goddard explained the requirements that necessitated the different types. The meeting concluded with the showing of three-dimensional color pictures taken over various parts of the country. Colonel Goddard explained that such photographs were primarily for use in intelligence work.

Hampton Roads Section

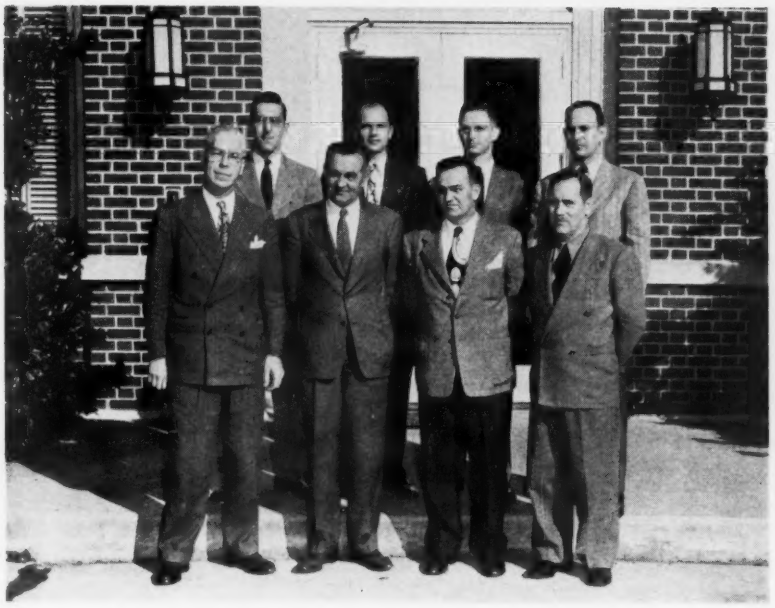
George White, *Secretary*

Approximately 100 members of the Hampton Roads Section, at a meeting held November 13, elected an Advisory Board consisting of the following men: Dr. H. J. E. Reid, Director, Langley Aeronautical Laboratory, N.A.C.A.; Melvin N. Gough, Chief of Flight Research Division, N.A.C.A.; Jean A. Roche, Technical Assistant to Engineering Field Officer, Air Materiel Command, Langley Air Force Base; and John Stack, Assistant Chief of Research, N.A.C.A.

Chairman Douglas A. King announced the appointment of the following committee chairmen: Membership, Robert W. Miller; Program, Robert K. Souter; and Nominating, Francis M. Rogallo.

Following the business meeting, members witnessed a spectacular Indoor Air Show staged by the Brainbusters Model Club in the N.A.C.A. Activities Building. Several excellent flights of indoor contest models were made, and Eugene Hartmangruber, Brainbusters' President, demonstrated a CO_2-powered model flying around a pylon. Other flight demonstrations included a helicopter, an autogyro, gliders, and rubber-powered models. In addition to the flying exhibitions, there was a huge static display of nearly 50 models of all types and sizes, including radio-controlled models, tiny fly-powered models, an ornithopter, and the more conventional gas- and rubber-powered models. An interesting exhibit of model gasoline engines illustrated the range of sizes in use.

The Brainbusters Model Club is widely known for its activity and the achievements of its members, several of whom are national record holders. In charge of arrangements for the Air Show program was Jesse F. Shepherd, and the events were ably announced and described by Joe W. Dodson.



HAMPTON ROADS SECTION: *Members of the Advisory Board and Section officers are shown in the front and rear rows, respectively. In the front row (left to right) are: Dr. H. J. E. Reid, Director, Langley Aeronautical Laboratory, N.A.C.A.; John Stack, Assistant Chief of Research, N.A.C.A.; Melvin N. Gough, Chief, Flight Research Division, N.A.C.A.; and Jean A. Roche, Technical Assistant to Engineering Field Officer, Air Materiel Command, Langley Air Force Base. In the back row (left to right) are: Chairman, Douglas A. King; Vice-Chairman, Charles F. Merlet; Secretary, George White; and Treasurer, William Solomon.*

Los Angeles Section

H. A. Storms, *Secretary*

The regular meeting was called to order at 8:00 p.m. on October 19 in the Institute Auditorium by P. A. Colman, Chairman. James L. Straight, who recently resigned as I.A.S. Assistant Director, was presented with a farewell gift from the local section, and Ernest W. Robischon, the newly appointed Western Manager, was introduced to the attending members.

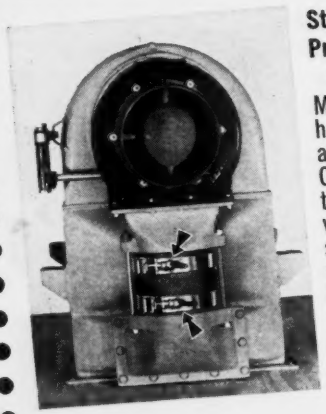
Mr. Colman then introduced W. J. Gaugh, Aerodynamicist, Northrop Aircraft, Inc., who, with the assistance of J. K. Slap, also of Northrop, presented a paper entitled "Aerodynamic Aspects of the Aeroelastic Problem."

The coauthors have developed a method for determining the final equilibrium lift distribution across an elastic swept wing. The undeformed wing air loading was used in conjunction with the simple beam theory to obtain a spanwise angle-of-attack distribution due to this loading. The lift corresponding to this angle of attack was reapplied to the wing, and an additional increment in angle distribution was obtained. The process was continued until two successively calculated angle-of-attack distributions were equal within the desired limits of accuracy. For this method, only the first three or four adjustments need be considered in order to obtain a good engineering estimate of the final equilibrium lift and angle-of-attack distributions.

Any method of calculating the lifting-line load and spanwise strength distributions can be used with this method, and the effect of built-in wing twist, wing mass, and control-surface load distributions can be included. The method can be converted to matrix notation using influence functions and solutions obtained by using automatic machine calculations. An even more important advantage is that the final angle-of-attack distribution can be expressed as an explicit function of the free-stream dynamic pressure. Several other interesting and convenient ramifications were outlined.

Good agreement was obtained between some full-scale wind-tunnel results on a high-speed ratio, sweptback wing

ENGINEER'S NOTEBOOK



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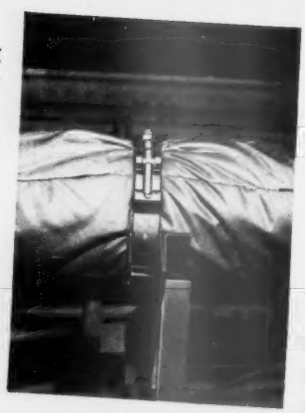

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1

and the theoretical results obtained from the above method.

Approximately 150 members and guests were in attendance at this meeting.

▶ A specialists' meeting was held at the Institute Building on November 2, with Dr. N. F. Parker presiding. Floyd Steele, President, Computer Research Corporation, presented the evening's discussion, "The Engineering of Purpose and the Nature of the Purposing Machine."

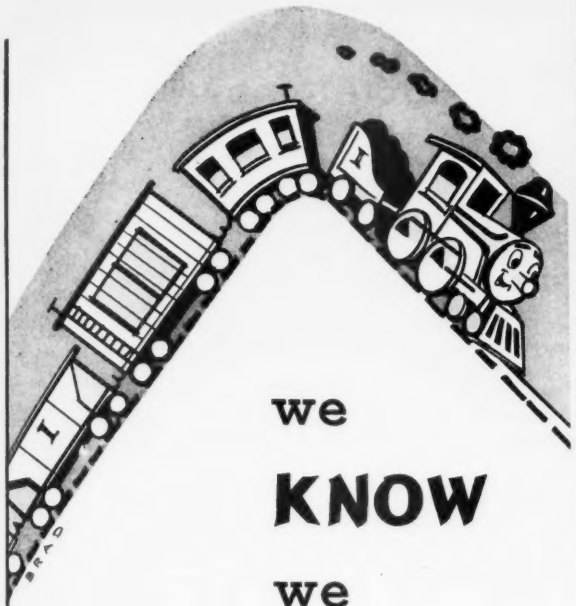
Mr. Steele defined a "purposive machine" as a device that can make judgments between two or more things and make decisions based on such judgments. A digital computer is such a device.

A prominent use of purposive machines will be in their applications to engineering design methods. It is probable that, within 5 years, desk calculators will be available for the use of individual engineers. On the basis of present knowledge, this machine will probably employ a magnetic memory principle. These calculators will be particularly useful in the solution of reiterative problems. Within another 10 or 15 years, the individual calculator will begin to be replaced with larger, central computers. These computers will tend to replace man for the repetitive engineering jobs.

A second application of purposive machines will be as new engineering components such as might be used in automatic pilots. In the beginning, these devices probably will use analog sensing units; later on, digital sensing devices will probably be available.

An increasing use of purposive machines in automatic machinery will be noted sometime in the future, and probably within a generation, completely automatic factories will begin to appear. The ability to solve nonlinear problems by reiterative methods will cause most problems to be solved in this manner rather than by linearizing methods. There will be concurrent tendency in engineering education to emphasize reiterative methods at the expense of classical differential equation methods. There will be necessity for the compilation of extensive data, probably in coded forms, for use with the computers.

As more time passes, the engineer will find himself in the position of designing engineering methods rather than specific designs. By then, most of the ordinary design computations can be handled directly by the computers. Eventually, the technician will be in the place of power historically held by those controlling industrial production.



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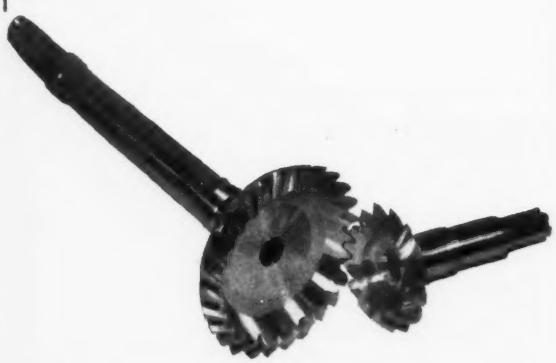

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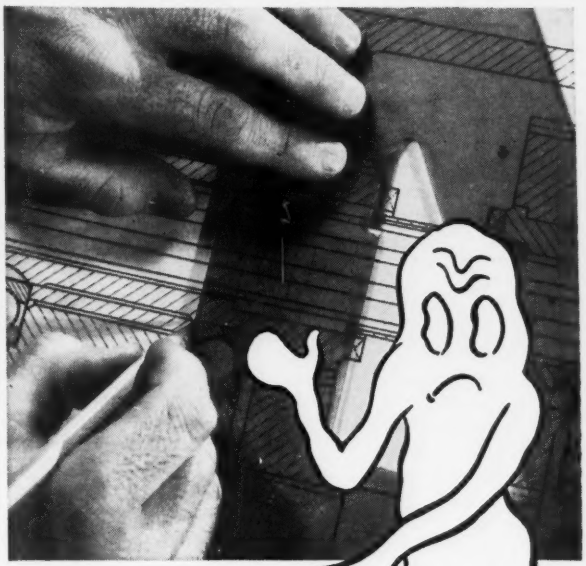

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Montreal Section

G. E. Otter, *Secretary*

The second meeting was held in the International Aviation Building on November 30. Approximately 80 members and guests attended.

Professor Mordell addressed the meeting on the subject, "Some Problems of the Aircraft Gas Turbine." Professor Mordell, who was a member of the original gas-turbine design team at Rolls Royce, has contributed to the development of all Rolls Royce gas-turbine engines presently in production. He joined McGill University in 1947 and is now Director of the Gas Dynamics Laboratory and Associate Professor of Mechanical Engineering.

Professor Mordell emphasized that the era of the simple gas turbine is past. The requirements for better specific fuel consumptions and higher thrusts per unit of frontal area are leading to complications in the gas-turbine engines equal to those of the reciprocating engine. Such complications will probably include some of the following: blade cooling with the associated glands and seals, radiators, radiator flaps, compounding the compressors to permit starting with high compression ratios and to provide flexibility of operation, compressor bleeds, higher operating temperatures, more auxiliary drives, etc. A lively discussion followed the meeting.

The Chairman, John Drummond, announced that E. B. Schaefer had been appointed Chairman of the Program Committee, with A. E. Ades and E. H. Higgins to assist him. A technical session is planned for the April meeting and local members were invited to submit résumés of papers for review.

The Chairman also announced that W. B. Boggs had been appointed Chairman of the Membership Committee and of the Nominating Committee.

New York Section

R. P. Harrington, *Secretary*

The second fall meeting was held on November 9. About 275 members and guests attended the lecture by Igor I. Sikorsky, Engineering Manager, Sikorsky Aircraft Division, United Aircraft Corporation. Mr. Sikorsky pointed out how well the value of the helicopter had been demonstrated and proved during the present war in Korea. He cited commendations of various military personnel regarding the operation and contributions of the helicopters and went on to discuss the present and future size and limitations of helicopters, mentioning that machines of between 50,000 and 100,000 lbs. gross weight might well be constructed in the near future. He compared the possible types and configurations of such large machines and indicated that speeds up to 200 or 300 m.p.h. might be accomplished, although they were more likely to remain around 150 or 200 m.p.h. Presentation of a film completed the lecture.

Attention Members!

All members of the Institute are invited to submit material concerning their activities for publication in the "News of Members" columns of the *Aeronautical Engineering Review*. Responsibility for new developments, awards or honors received, and appointments to new or additional positions are some of the items that your editors believe are of interest to other I.A.S. members. A brief letter or postal card giving exact details will be sufficient. Photographs accompanying news items will be welcomed and will be used where practicable.

Items submitted will be considered on the basis of their timeliness and general interest. Correspondence should be addressed to the News Editor, *Aeronautical Engineering Review*, 2 East 64th Street, New York 21, N.Y.

Philadelphia Section

Dale Hamilton, *Secretary*

The annual joint meeting with the Franklin Institute was held on November 1. Hugh Mulvey, Chairman, introduced the speaker, Frederick Lee, Deputy Administrator, C.A.A.

Mr. Lee discussed the problems and solutions of air navigation and traffic control as being worked out by the C.A.A. Greatly increased air traffic after World War II created the problem of modernizing the navigation and air-traffic-control techniques. New techniques and electronic devices developed during the war are aiding in the solution of the problem. Looking toward the future, the jet transport will necessitate more precise let-down procedures.

In an attempt to alleviate these problems, the C.A.A. is installing nationwide Instrument Landing Systems, Visual Omnidirectional Ranges, V.H.F. communications, Distance-Measuring Equipment, and Ground-Controlled Approach systems.

The Air Navigation Development Board was set up to help establish a common system of control for air navigation and air traffic, which was necessary for the integration of the military service and C.A.A. flights. Franklin Institute has assisted the A.N.D.B. with these problems.

▶ The December 6 meeting was held in conjunction with the A.O.P.A. Total attendance was about 40 at the John Bartram Hotel, following a "Meet the Speaker" dinner at the Philadelphia Engineers' Club.

Guest speaker was Walter C. Jamouneau, Chief Engineer, Piper Aircraft Corporation, whose subject was "Design Improvements to Increase the Safety and Utility of Personal Aircraft."

Mr. Jamouneau outlined the factors affecting the design of personal airplanes to provide safety, utility, and low cost. Specifically, the factors of speed, comfort, reliability, safety, simplicity of operation, maintenance cost, and first cost were discussed in detail.

The personal-plane business is poor, but the market is good as now maintained by businesses requiring airplanes. Utility is relative, and, if airports exist and there is a need for speed, airplanes with speeds of 120–150 m.p.h. are justified.

Many new developments in special airfoils, high-lift devices, etc., are not available to small aircraft companies because they lack the funds for research and development and for the vast amount of engineering involved in obtaining type certificates on radically new models. Personal aircraft are more likely to evolve by small stages, as has the automobile.

Makers are concentrating on providing comfort, reliability, simplicity of operation, and as low a cost as possible. Items such as interior appointments, ventilation, visibility, comfortable and adjustable seats with lots of leg room, and noise reduction are now receiving special attention. That personal airplanes are now reliable is evidenced by the late Bill Odom's flights from Hawaii to the U.S. and the flight of two Piper Cruisers around the world. Personal aircraft must be kept simple to operate so that the private "Sunday-pilot" can safely handle them. Safety devices such as stall-warning indicators have a place, but they should not be depended upon completely. Rather, gentle stall characteristics or "stallproof" ships will assure that the amateur pilot will not get into trouble. The tricycle landing gear or the cross-wind gear are also helpful, but costs must be held down. Cost is a major problem. Designers find it impossible to provide everything

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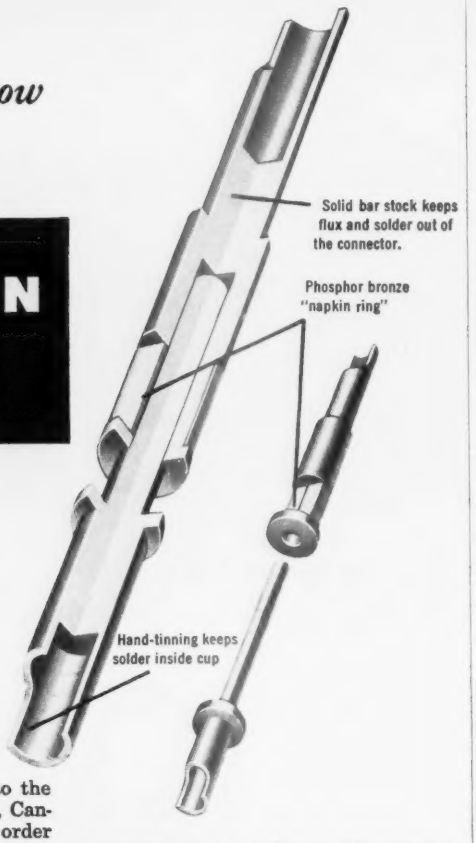
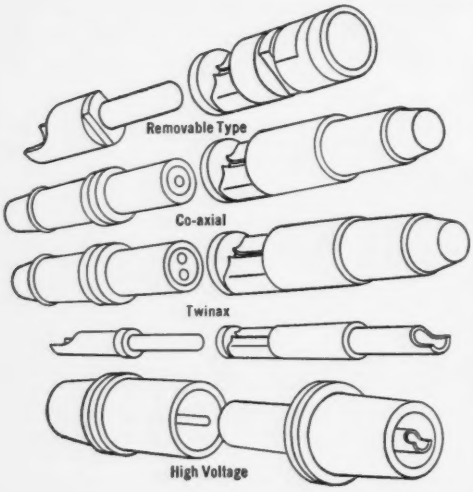
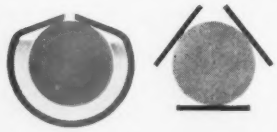

Solid bar stock keeps flux and solder out of the connector.
Phosphor bronze "napkin ring"
Hand-tinning keeps solder inside cup

Because the contact is the key to the success of any electric connector, Cannon has always applied the highest order of skill and care to this all-important detail. Cannon pin and socket contacts are all precision machined from solid bar stock. Silver or gold plating maintains high conductivity after years of constant use. Phosphor bronze "napkin ring" of the socket keeps pressure on large areas of heavy metal, preventing current loss. There are no thin metal tangent contact points in Cannon contacts. (See below). Solder cups are carefully tinned by hand to keep the solder inside the cup. Cannon socket contacts are full floating to assure perfect alignment. You'll find these design features throughout the great variety of precision contacts used in all Cannon connectors. For real value demand Cannon.





Cannon design (above left) makes contact on large, heavy metal surfaces. Current is not carried through spring section. In Cannon Connectors there are no thin metal tangent contact points, like the design shown at right.

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Some interesting movies of a tricycle landing-gear drop test were shown, as well as color slides of Piper's 1951 models. A question-and-answer period followed Mr. Jamouneau's talk.

Pittsburgh Section

R. H. Fields, *Secretary*

The December 6 meeting was called to order by the Chairman of the Organizing Steering Committee, G. F. Towner. The minutes of the organizing meeting were read and approved.

Thomas J. Meskel, Manager, I.A.S. Member Services, was introduced, and a general discussion of the organization of a section followed. He explained that the response by local members of the Institute (by postcard) constitutes a petition by the members for a Pittsburgh Section. Mr. Meskel then stated that, upon election of officers and adoption of a constitution, the Pittsburgh group would be an official section. The standard constitution was adopted by the unanimous vote of the members. A quorum was present at the meeting, and therefore the election of officers proceeded, with the following results: Chairman, G. F. Towner; Vice-Chairman, R. A. Wells; and Secretary-Treasurer, R. H. Fields. Members of the Advisory Board include: G. T. Ringe (Chairman), Prof. C. C. Yates, Major M. F. Behar, A. M. G. Moody, and J. E. Chikar. Mr. Ringe is also Chairman of the Program Committee.

A movie of the 1949 British Air Show at Farnborough was shown, and the meeting was then adjourned.

St. Louis Section

Jack A. Durand, *Secretary*

The October 17 meeting was held at the Engineers' Club of St. Louis. Don Berlin, Chairman, presided at the meeting, and about 150 members and a group of students from Parks College of Aeronautical Technology's I.A.S. Student Branch attended. After a short business meeting, B. G. Bromberg, of the Program Committee, introduced Art Lambert, Aerodynamics Department, McDonnell Aircraft Corporation, who gave a talk on "High Mach-Number Aircraft."

Mr. Lambert's talk was divided into two parts: (1) high Mach Number characteristics of airplanes and (2) considerations of high top-speed optimum (target) design. In the first part, he presented equations governing the relations between pressure, velocity, and area changes for compressible flow and then went on to show how these relations govern the type of flow over an airfoil at

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high speeds. He presented diagrams that showed the variations of the aerodynamic characteristics of the wing as functions of the wing shape and Mach Number. In the discussion of the target design for the high-speed plane, Mr. Lambert showed the optimum configuration as determined from theory and gave reasons why such a configuration was needed for the best design. He concluded by remarking that the present high-speed airplane is not the optimum design as far as theoretical developments are concerned.

After the talk, a color sound film on the *Facilities of the N.A.C.A.* was shown.

▶ The November 21 meeting was held at the Engineers' Club. Dave Lewis, Vice-Chairman of the Section, presided. Professor Kippenhan, Membership Committee Chairman, reported that his Committee was taking steps to solicit new members for the Section. Posters have been prepared and are to be displayed at McDonnell Aircraft Corporation and Emerson Electric Company. Letters are to be sent to prospective members.

The speaker for the evening was Arthur Lowell, Guided Missile Department, McDonnell Aircraft Corporation, who gave a talk on "The Evolution of a Guided Missile Design." Mr. Lowell began with the statement that the data obtained from missile design and experimentation are used extensively in aircraft design today. He explained that, although much information is classified material, the matter of method or general evolution of a typical missile is not classified. A diagrammatic breakdown of the spiral arrangement of the steps necessary in a missile design was presented, and the fact that each part in the design is a definite function of some other part was emphasized. Mr. Lowell stated that the missile is an example of specialization. There is no "all-around" missile; each job has its own missile. There is no limit on the design or size, take-off or flight attitude.

Mr. Lowell then went on to outline the design procedures for an air-to-air military missile from assumed military requirements. The military missile is one that is pilotless, one that can be controlled, and one that can be used for tactical work. As in aircraft design, the missile should be as light and small as possible, and since it is to be used as a tactical object, its design as a weapon is an important consideration. Any such missile must incorporate the three "graces" of design—producibility, serviceability, and reliability, the last probably being the most important of the three. Mr. Lowell stated that four main types of control of a missile are used: (1) the radio beam; (2) radiation or beam rider; (3) semiactive radar beam in which a parent plane carries radar equipment to guide the missile; and (4) active radar in which the missile carries its own radar. The engine for the missile should be as small and light as possible, with the ram-jet or rocket engine being the most practical. For a missile with a speed of about Mach Number 2, the rocket engine using a solid fuel and launched from a parent plane is considered as a feasible tactical missile.

Mr. Lowell concluded by stating that, after the preliminary design is decided upon, the problems of financing the project, integration of parts, simulated tests in wind tunnels of aerodynamic configurations, and ground launching and flight tests must be undertaken and solved.

A sound color movie that showed typical test missiles followed the talk.

Washington Section

C. D. Auld, *Secretary*

The first meeting of the 1950–1951 season, November 13, was sponsored by the Aircraft Industries Association. Admiral Ramsey, of the A.I.A., served as Honorary Chairman. He briefly outlined the purpose and functions of the A.I.A.

The general theme of the meeting was "The Future of the Helicopter and the Private Plane." The section was particularly fortunate in having Igor I. Sikorsky speak on the helicopter and J. T. Geuting, Jr., Manager, Personal Aircraft Council, A.I.A., speak on the future of the private plane.

Mr. Sikorsky discussed the basic helicopter and its several ramifications, compound (wing and rotor) and the convertaplane. He then continued to a discussion of the future of the basic helicopter chiefly in terms of size, speed, and configuration. Helicopters of 100-ton gross weight may be considered the limit of size. In Mr. Sikorsky's opinion, the single-rotor configuration is optimum. However, he pointed out that research should not be limited to a single configuration. Speeds of the basic machine are not expected to exceed approximately 160 m.p.h.

Mr. Geuting prefaced his talk with an outline of the present status of the private plane. He then discussed the foreseeable future of this phase of aviation, stressing the fact that the private plane is not now, nor is likely to become, "everyman's" form of transportation. The solid market lies with those for whom this form of transportation is an economic venture. The present market can be considerably expanded in view of the fact that only 5 per cent of the population have ever been up in an airplane. Of the many problems confronting the private-plane industry, Mr. Geuting discussed principally the present lack of

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basic research in low-speed aerodynamics and the obstacle presented by the language of aviation which, in some manner, must be made intelligible to the layman. He also considered the small-field landing and take-off problem in terms of the limitations imposed on the airplane and the effects of location of personal-plane landing fields on the community.

Both talks were favorably received as evidenced by the extent of the discussion following their presentation. The meeting was attended by 200 persons.

Wichita Section

Melvin H. Snyder, Jr., *Secretary*

Henry F. Waring, Jr., spoke on "The Development of the L-19" at the November 2 meeting. Hank Waring is Engineering Test Pilot, Cessna Aircraft Company. He demonstrated the L-19 to the Air Force and Army inspection teams during the liaison plane competition at Wright-Patterson Air Force Base and at Fort Bragg.

Mr. Waring described the steps involved in the design of the L-19. He indicated that the designers started with the present private plane, the Cessna 170, and, through extensive modifications to fit it for military use, arrived at the present configuration of the L-19. He described the flight test and the competition that the Cessna plane won. The L-19 is currently in production at the Cessna plant, and the first production model was accepted recently by the Army and Air Force joint acceptance board.

There were 62 members and guests present at the meeting.

Student Branches

Cal-Aero Technical Institute

The October 24 meeting was called to order by Chairman William Lee. Ernest W. Robischon, I.A.S. Western Manager, who was introduced by C. T. Reid, Assistant to the President, Grand Central Aircraft Company, spoke briefly on the advantages of I.A.S. Student Membership. Mr. Robischon then presented Thomas Meyers Hamilton, Wittaker Company, with the biannual I.A.S. Scholarship Award as the outstanding graduate in the 6-month period, April to September, 1950. The speaker was Carroll Gordon, North American Aviation, Inc., who discussed "Power Controls, the Necessity for Them and the Approach to Their Design." The meeting was attended by 90 persons.

California State Polytechnic College

Two motion pictures were shown at the October 26 meeting: an Allis-Chalmers Manufacturing Company release, *Tornado in a Box*, and a Boeing Airplane Company release, *The Story of the Stratocruiser*. Chairman M. V. Price presided; 23 members and two guests attended.

At the November 9 meeting, 35 members and three visitors heard Student Member George F. Rugge speak on various aspects of the atomic bomb and Student Member Donald J. Hatfield present a talk on "Track-Type Landing Gear." Douglas Aircraft Company, Inc., films on *Operation Vittles*, *Operation Airborne*, *C-124*, and *Douglas D-558* were shown. Chairman Price presided.

The Catholic University of America

Chairman J. Carney opened the meeting of November 15, which was attended by 42 persons. Dr. L. E. Smull, Director of Student Placement, N.A.C.A., gave a lecture, illustrated by slides, on "Flight Faster Than Sound."

▶ Chairman Charles J. Carney, who presided at the December 6 meeting, introduced the guest speaker, Peter Olmstead, Design Engineer, Bureau of Aeronautics, U.S. Navy. Mr. Olmstead's topic was "Design Performance and Performance Curves," and he spoke on the design procedure followed in the Navy in preparing specifications of planes and engines to be contracted to private companies. A film, *Development of the Flying Wing*, followed the discussion after the talk. Twenty-one persons attended.

Clarkson College of Technology

Twenty-one persons attended the November 15 meeting at which Chairman Robert C. Waters presided. Guest speaker Vincent G. Redmond, Assistant Professor of Mechanical Engineering, Clarkson, spoke on "Aircraft Design." Two films, *Jet Propulsion* and *High-Altitude Flight and Aerobatics*, were shown.

University of Colorado

Andrew J. Prokop, Acting Supervising Agent, Aviation Safety Unit, C.A.A., spoke on the "Investigation of Aircraft Accidents." Chairman Myron J. Miller led the November 20 meeting; 26 persons attended.

Georgia Institute of Technology

At the October 18 meeting, Donnel Dutton, Head of the Aeronautical Engineering Department, Georgia Tech, gave a lecture on "Some Interesting Facts in the History of the Aeronautical Engineering Department at Georgia Tech." Chairman Thomas P. Browne presided; 50 persons attended.

University of Illinois

Dr. A. C. Williams, Research Associate Professor of Psychology, University of Illinois, presented a lecture on "Aircraft Instrument Display." Chairman Harvey A. Wallskog presided at the November 8 meeting.

Louisiana State University

About 50 persons attended the showing of films that followed the November 3 meeting. These films included the *ABC of G*, *University of Flying*, and *Faster Than Sound*. Chairman Robert Dawson presided at the meeting.

Northrop Aeronautical Institute

The following officers have been elected: Chairman, H. D. Moran; Vice-Chairman, W. Tucker; Secretary, M C. Long; and Treasurer, T. Patris.

University of Notre Dame

The November 9 meeting was called to order by Chairman Joseph Lotta, who introduced the speaker, Dr. Hugh L. Dryden, Director, N.A.C.A. Dr. Dryden's talk on the "Problems of Supersonic Flight" was followed by a film, *N.A.C.A. Laboratories*. Forty persons attended.

The Ohio State University

The 1950–1951 officers were introduced at the October 18 meeting: Chairman, Lee V. Gossick; Vice-Chairman, Robert Heninger; Secretary, Richard Miller; Corresponding Secretary, Andrew Beke; and Treasurer, Dave Ulry. Sixty persons attended.

▶ Chairman Gossick led the November 8 meeting at which Major John P. Lisack, U.S.A.F., Officer in Charge of Maintenance Instruction, Department of Military Science, O.S.U., spoke on "Maintenance Factors in Design of Aircraft." Several films were shown; forty-five persons attended.

The University of Oklahoma

Two films, *Principles of Flight* and *Problems of Flight*, were shown at the November 15 meeting. Chairman Harold G. Coles, Jr., presided; 50 persons attended.

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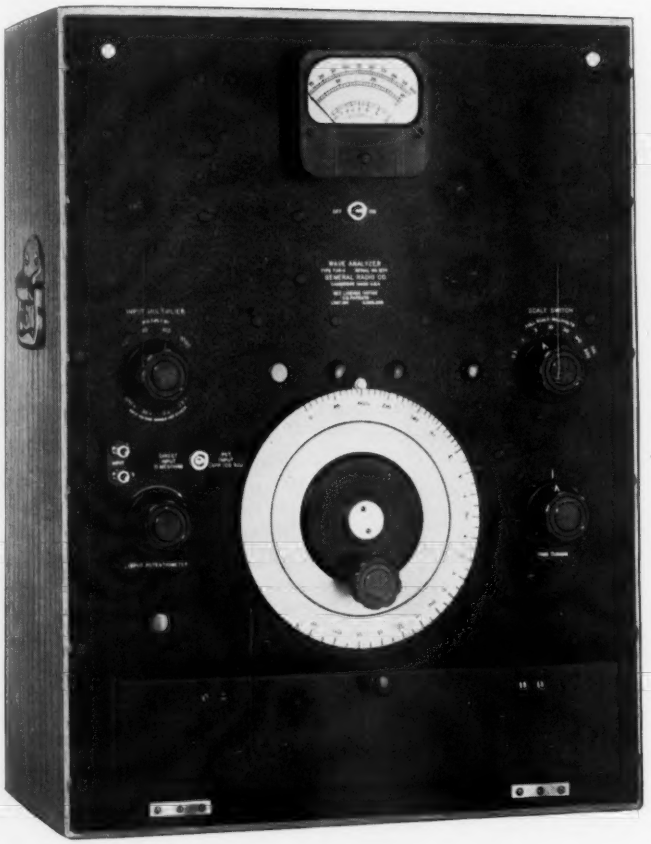

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The Pennsylvania State College

Chairman William B. Hendershott opened the October 25 meeting at which two films, *British Aircraft Review of 1949* and *Jet Assisted Take-Off*, were shown.

Seventy-two persons attended the meeting.

Stanford University

Three films were shown at the October 31 open meeting. They were *Air Progress*, *The Third Pillar*, and *Dividends for the Future*. Chairman John S. Traynor presided. Twenty-five persons attended.

Stewart Technical School

New officers were elected at the November 15 meeting: Chairman, Philip Vantoci; Vice-Chairman, Roger B. Seybel; and Secretary-Treasurer, Gerald J. Veltre. Retiring Chairman Stanley Okarma, who presided at the meeting, presented a résumé of Igor Sikorsky's talk on "An Analysis of the Helicopter Present and Potential," which was originally given at the November 9 meeting of the I.A.S. New York Section. Twenty persons attended.

Syracuse University

The following films were shown at the November 29 meeting: *Jet Propulsion*, *Torpedoes in Action*, *What's That Plane*, and *Prepare for Ditching*. Chairman George Schmanke presided; 13 persons attended.

University of Tulsa

The meeting of November 16, attended by 32 persons, was opened by Chairman John Beadling. H. A. Miller, a 1949 Tulsa graduate, spoke on his duties and the functions of the Engineering Department at American Airlines Repair Depot. Mr. Miller is an Assistant Engineer at the Repair Depot. Three films were shown after the lecture: *Wright Builds for Air Power*, *Jet Propulsion*, and *Republic P-47 Aerobatics*.

University of Washington

At the October 5 meeting, Dr. K. H. Hohenemser, Chief of Aerodynamics, Helicopter Division, McDonnell Aircraft Corporation, spoke on the "Dynamic Problems in Helicopter Design." The meeting was led by Chairman John R. Gintz; 30 persons attended.

Members Elected

The following applicants for membership or applicants for change of previous grades have been admitted since the publication of the list in the last issue of the REVIEW.

Transferred to Associate Fellow Grade

Lagerstrom, Paco A., Ph.D. in Math., Assoc. Prof. of Aeronautics, California Institute of Technology; Consultant, Douglas Aircraft Co., Inc. (Santa Monica).

Littell, Robert E., B.S., Chief, Propulsion Div., N.A.C.A. (Washington, D.C.).

Elected to MEMBER Grade

Arnold, Gottfried M., Dipl. Ing., Scientist, Wright-Patterson Air Force Base.

Beck, W. Nelson, B.A., Electronics Engineer, Globe Aircraft Corp.

Carroll, Thomas D. R., Flight Lt., Stress Officer, British Overseas Airways Corp.

Claflin, Waldo M., M.S.M.E., Engineer, Instrumentation Group, Grumman Aircraft Engineering Corp.

Fahnestock, Louis, III, B.S., Manager, Engineering Dept., Fairchild Aircraft Div., Fairchild Engine & Airplane Corp.

Garrett, John C., President & Founder, The Garrett Corp. (AiResearch Mfg. Co. Div.).

Glines, John E., Asst. to the Director of Engineering, Ryan Aeronautical Co.

Gunthorp, Seth, M.A. (Mathematics), Research Engineer, Consolidated Vultee Aircraft Corp. (San Diego).

Holroyd, Wilfred B., Asst. Engineer, Technical Sales Staff, Air Control Installations, Ltd.

Islamoff, Ilia, E.E., Superintendent, Sheet Metal, Pusey & Jones Corp.

Knapp, Willard A., Jr., M.S.M.E., Project Engineer, Non-Rotating Engine Branch, Power Plant Lab., U.S.A.F., Wright-Patterson Air Force Base.

Lampton, Glen T., B.S., Design Staff Engineer, Hughes Aircraft Co.

Lindsey, Wilbur R., Jr., M.S.E. in Ae.E., Captain & Pilot, U.S.A.F.; Project Officer, Guided Missiles Section, Holloman Air Force Base.

Ruckstahl, Robert E., Chief Draftsman, Westinghouse Electric Corp.

Schaid, Rodney J., M.S.M.E., Mechanical Engineer, Aerial Measurements Lab., Northwestern University.

Shaffer, Leonard, Weights Analyst, Lockheed Aircraft Corp.

Silsby, Norman S., B.S. in M.E., Aero. Research Scientist, N.A.C.A. (Langley Field).

Vaeth, J. Gordon, B.A., Aero. Engineer, Special Devices Center, Office of Naval Research.

Wener, Nathan Leonard, B.M.E., Flight Test Engineer, Test Engineering Sub-Div., Flight Research Section, Aerodynamics Branch, Air Materiel Command, Wright-Patterson Air Force Base.

Wright, Harold V., President, Canadian Wright, Ltd. (Montreal).

Transferred to MEMBER Grade

Cooper, Morton, B. of Ae.E., Aero. Research Scientist, N.A.C.A. (Langley Air Force Base).

Dehlinger, Hans, B.S.E. (M.E.), Senior Vibrations Engineer, The Glenn L. Martin Co.

Eisert, Fred J., Capt., U.S.A.F.; Jet Engine Unit Chief, Power Plant Branch, Wright-Patterson Air Force Base.

Frei, Wallace M., B.S. in Ae.E., Flight Test Engineer, Dept. of Commerce C.A.A.

Heaton, Clyde E., B.S. in Ae.E., Lt. (j.g.) & Aerological Officer, U.S.N.R.

Holback, George E., M. of Ae.E., Supervisor, Materials Lab., The Glenn L. Martin Co.

Koetsch, Julius F., M.Ae.E., Capt. U.S.M.C.; Assigned to the University of Minnesota for courses leading to Dr. of Philosophy in Ae.E.

Krug, Edwin H., M.S. in Ae.E., Aerodynamicist "B," Consolidated Vultee Aircraft Corp. (Fort Worth).

Meledy, Thomas A., B.S., Weight Control Engineer "A," North American Aviation, Inc.

Morgan, Antony J. A., M.S., in Aero., Research Asst., California Institute of Technology.

Newton, Floyd C., Jr., B.Ae.E., Group Leader, Performance Group, Aerodynamics Section, Douglas Aircraft Co., Inc. (El Segundo).

Osofsky, Irving B., B. of Ae.E.

Schneyer, Raymond I., M.S.E. (Aero. Eng.), Asst. to the Head of Gas Dynamics Facility of A.E.D.D., ARO, Inc.

Spraitz, Edward F., B. of Ae.E., Aero. Engineer GS-5, National Bureau of Standards.

Swift, Selma C., B.S., Research Engineer, Hughes Aircraft Co.

Thompson, Hugh B., M.Ae.E., Aerodynamicist, Northrop Aircraft, Inc.

Wackelin, Harold L., B.S. in Ae.E., Aerodynamicist, Aircraft Div., The Globe Corp.

Werner, Frank D., M.S. in Ae.E., Lecturer and Scientist, Dept. of Aero. Engineering, University of Minnesota.

Wetzel, Albert J., M.S. in Eng. (Aero.), Major, U.S.A.F.; Design & Development Staff Officer, Hq., A.F.S.W.P. (Washington, D.C.).

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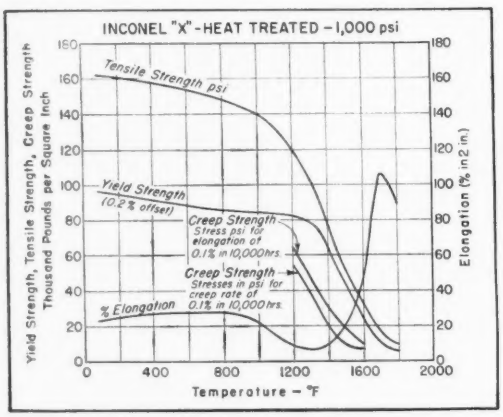
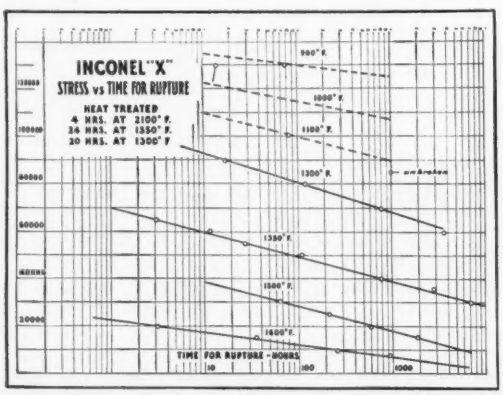


Short-time high-temperature properties of fully heat-treated Inconel "X".



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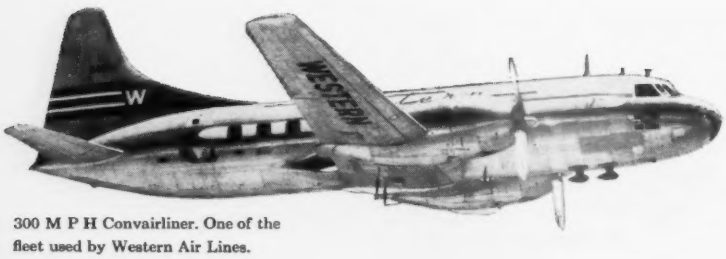

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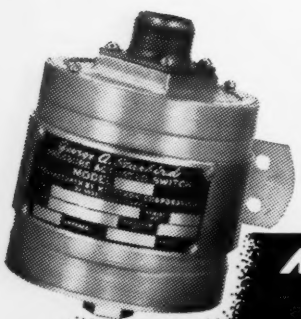

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Elected to Associate Member Grade

Dodge, Beverly A., News Editor, *Aeronautical Engineering Review*, The Institute of the Aeronautical Sciences, Inc.

Morgan, Alan C., Director, Customer Relations Div., & Asst. Secretary, Aircraft Mfg., Northrop Aircraft, Inc.

Satz, Marvin W., Production Engineer & Purchasing Agent, Safe Flight Instrument Corp.

Sims, Arthur G., Sales Representative, Canadair, Ltd.

Elected to Technical Member Grade

Davenport, Robert E., Weight Analyst, Douglas Aircraft Co., Inc. (Santa Monica).

Hahn, Paul G., B.S. in Ae.E., Vibration Analysis Engineer, The Glenn L. Martin Co.

Macdonald, Robert S., B.S., Jr. Mechanical Engineer, Cornell Aero. Lab., Inc.

Pond, James C., B.S. in Ae.E., Jr. Engineer, Boeing Airplane Co. (Seattle).

Schumann, William A., B.S., Test Engineer, Allison Div., General Motors Corp.

Treleman, L. M., Design Draftsman, A. V. Roe Canada Ltd.

Ward, Jerry D., B.S., Aerodynamicist "A," North American Aviation, Inc.

Transferred to Technical Member Grade

Adams, John R., Engineering Draftsman "B," North American Aviation, Inc.

Beers, Henry S., Jr., M.S.E., Analytical Engineer, Performance Group, Research Dept., United Aircraft Corp.

Boothroyd, Vincent E., B.S. (Aero.).

Bridwell, William E., B.E. in A.E., Draftsman "B," Douglas Aircraft Co., Inc. (Santa Monica).

Briguglio, Rocco J., Senior Draftsman, Goodyear Aircraft Corp.

Brough, James N., B.A., Squadron Leader & Officer in Charge of Airplane Development, Hq., R.C.A.F. (Ottawa).

Carroll, John R., Jr., B.S.Ae.E., Asst. Engineer, General Electric Co.

Chamberlain, Stanley B., B.S., Jr. Engineer, Consolidated Vultee Aircraft Corp. (San Diego).

Corbert, James H., B.A.E., Draftsman "B," Wing Group, North American Aviation, Inc.

D'Amato, Richard, S.B. in Ae.E., Apprentice Stress Analyst, Grumman Aircraft Engineering Corp.

de la Vega, Elias G., B.S. in Ae.E. & B.S. in Industrial Management.

Diaconis, Nick S., M.S. in Ae.E., Aero. Research Scientist, Lewis Flight Propulsion Lab., N.A.C.A.

Drazich, George, B. of Ae.E., Jr. Engineer, Structures Dept., Consolidated Vultee Aircraft Corp. (San Diego).

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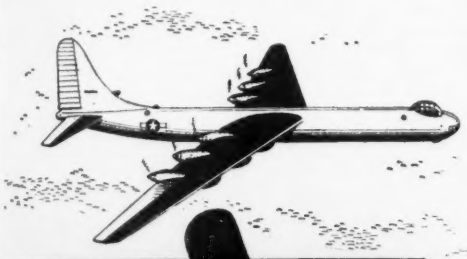

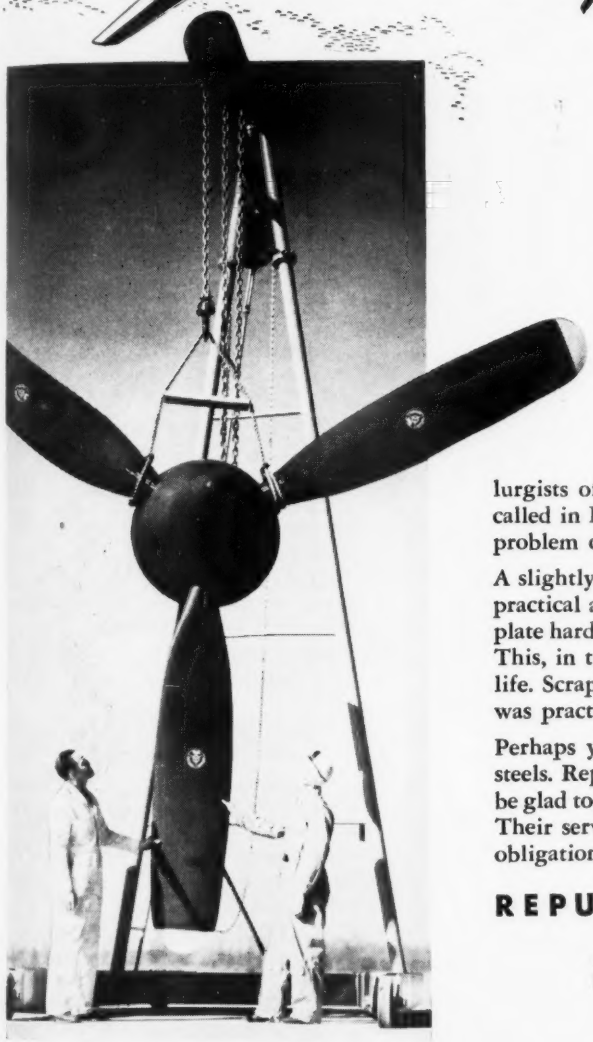

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Erickson, Donald D., A.A. in Ae.E., Jr. Designer, Goodyear Aircraft Corp.

Fisher, Roger L., B.S., Capt. & Sr. Pilot, U.S.A.F.; Field Maintenance Officer, 97th Maint. Sq., Briggs Air Force Base.

Fosdick, George W., B.A.E., Engineering Draftsman, Bell Aircraft Corp.

Giltner, Theodore, B.S. in Ae.E., Vibration & Flutter Engineer, Naval Air Experimental Station, Naval Base (Philadelphia).

Goldstein, Sid, B.Ae.E., Jr. Engineer, Controls Project, Boeing Airplane Co. (Seattle).

Hahn, Robert W., B.Ae.E., 2nd Lt. & Student Pilot, U.S.A.F.

Hartmann, John R., Detail Draftsman, Republic Aviation Corp.

Hayman, Norman W., B.A.Sc., Aero. Engineer, Grade IV, A. V. Roe Canada Ltd. (Malton).

Howieson, Jane, Jr. Engineering Draftsman, The Glenn L. Martin Co.

Hsu, Chieh-Su, Ph.D., Research Asst. Stanford University.

Jakubowski, Henry T., B.S.Ae.E., Structures Engineer, Bell Aircraft Corp.

Kerans, Donald E., A.A. in Ae.E., Jr. Design Engineer, Goodyear Aircraft Corp.

Kirschner, Donald J., B.Ae.E., Jr. Engineer "B," Boeing Airplane Co. (Seattle).

Lavin, Richard W., B.Ae.E., Engineering Detailer, Pesco Products Div., Borg-Warner Corp.

Lockie, Stanley M., Major & Aircraft Maintenance Officer, U.S.A.F.

Lyon, Richard D., B. of Ae.E., Detail Draftsman, Development Section, The Bullard Co.

Main, Charlton A., B. of A.E., Capt. & Naval Aviator, U.S.M.C.; Maintenance & Engineering Officer, VMT-2 Hq. Section, M.C.A.S. (El Toro).

Martinson, Ted, B.S. (Aero), Aero. Engineer GS-5, McClellan Air Force Base.

McKie, John S., B.S., Jr. Engineer "B," Aerodynamics Dept., Boeing Airplane Co. (Seattle).

Mohnsen, Earl H., Engineering Draftsman, William R. Whitaker & Co., Ltd.

Morse, John E., Capt. & Pilot, U.S.A.F.; Air Installations Officer, Landsberg Air Force Base.

Nesset, Reidmar, B.A.Sc., Lt., Royal Norwegian Air Force.

Nowak, Joseph J., B.S., Test Engineer, Bell Aircraft Corp.

Nozick, Harvey J., B.Ae.E., Design Engineer, Sikorsky Aircraft Div., United Aircraft Corp.

Nugent, Richard S., Lt. Col. & Air Inspector, U.S.A.F. (Brooks Air Force Base).

Okauchi, Kinge, M.Sc. (Aero.), Aero. Engineer, U.S. Naval Ordnance Test Station (China Lake).

Paine, Chester M., B. of Ae.E., Flight Test Analyst, Aerodynamics Group, Douglas Aircraft Co., Inc. (Santa Monica).

Phelan, Dennis J., B.S. in Ae.E., Jr. Detailer, McDonnell Aircraft Corp.

Prentice, Robert W., B. of A.E., Engineering Aide, Public Works Dept., Naval Air Station (Pensacola).

Prior, Richard O., B.Ae.E., Draftsman "A," Fuselage & Controls Group, Douglas Aircraft Co., Inc.

Rice, Milton E., B.S., Project Engineer, Structural Test Unit, Boeing Airplane Co. (Wichita).

Riedler, Alvin D., M.S. in Ae.E., Aerodynamics Engineer, Consolidated Vultee Aircraft Corp. (San Diego).

Rudy, Marion F., B.S., Engineering Asst., Hydraulics Training Program, Lockheed Aircraft Corp.

Sander, Paul K., Engineer, Electrical Group, North American Aviation, Inc.

Schnelker, Robert A., Wind Tunnel Operator, California Institute of Technology.

Shuda, Henry F.

Slomowitz, Samuel W., Senior Draftsman, Goodyear Aircraft Corp.

Sneeden, Ralph J., B.Ae.E., Test Engineer, Wright Aero. Corp. Div., Curtiss-Wright Corp.

Solinski, Francis J., B.S. in Ae.E., Senior Detailer, Electrical Installation, McDonnell Aircraft Corp.

Stahl, Laddie L., M.S.E., Major & Instructor, Guided Missiles School, U.S.A. (Ft. Bliss).

Stokes, Fred H., B.S. in M.E. (Aero.), Jr. Engineer, Regent Aircraft Corp.

Strittmatter, Willis C., Instrumentation Design Engineer, North American Aviation, Inc.

Underwood, Delmar G., A.A. in Ae.E., Jr. Design Engineer, Goodyear Aircraft Corp.

Vorachek, Jerome J., B.S.M.E. (Aero.), Jr. Development Engineer, Goodyear Aircraft Corp.

Wall, Charles A., B.S.Ae.E., 2nd Lt., U.S.A.F.; Design & Development Officer & Project Engineer, Air Materiel Command, Wright-Patterson Air Force Base.

Wannlund, Wallace R., B.S. in Ae.E., Structural Designer, Kaman Aircraft Corp.

Wendell, Herbert H., B. of Ae.E., Lt. (j.g.), U.S.N.; Air Group Maintenance Officer CVG-4, N.A.A.S. (Cecil Field).

Winnett, Alpha G., Jr., A.A. in Ae.E.

Zemlin, Jerry P., M.S. in Ae.E., Aerodynamicist "B," Douglas Aircraft Co., Inc. (Santa Monica).

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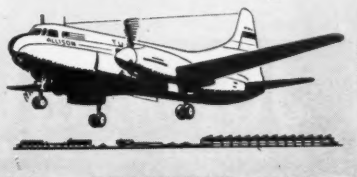

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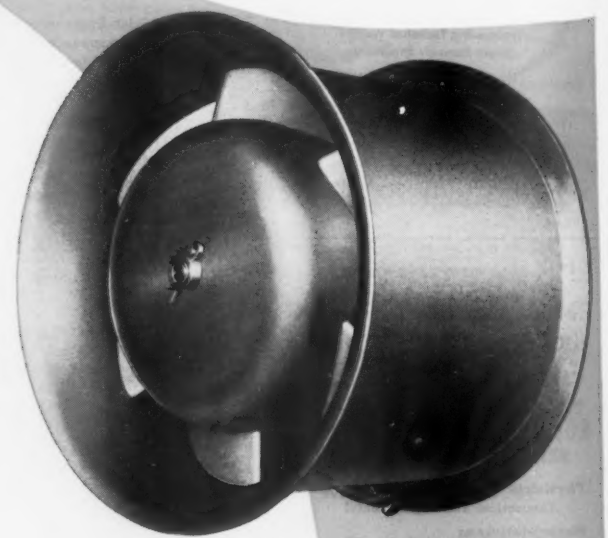

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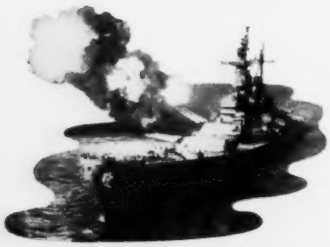

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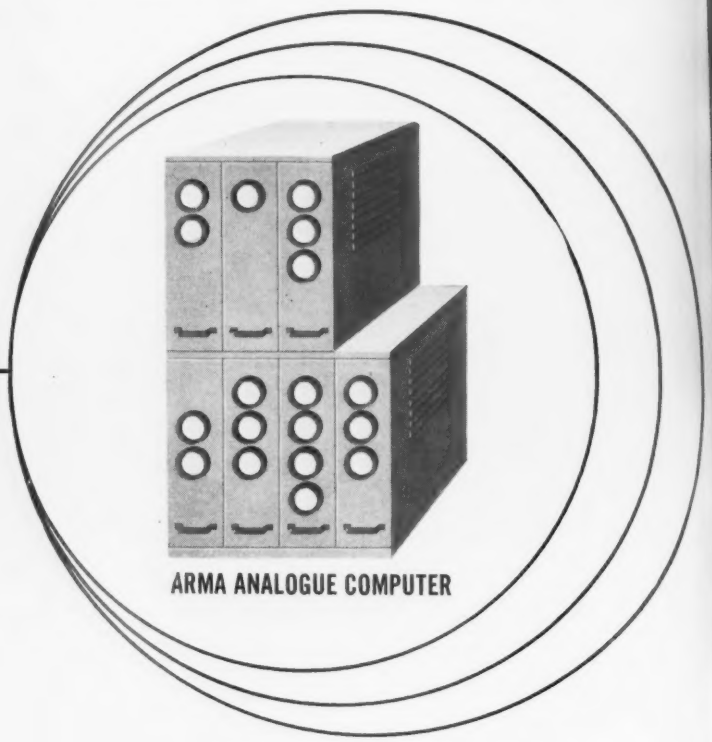

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7/16"	16-25	1-3/4"	10-20
1/2"	14-25	1-7/8"	10-20
9/16"	14-25	2"	9-20
5/8"	14-24	2-1/8"	9-20
11/16"	14-24	2-1/4"	9-20
3/4"	13-24	2-3/8"	8-20
13/16"	13-24	2-1/2"	8-20
7/8"	12-23	2-5/8"	8-20
15/16"	12-23	2-3/4"	8-20
1"	11-23	2-7/8"	8-20
1-1/16"	11-22	3"	8-20
1-1/8"	11-22	3-1/4"	8-16
1-3/16"	11-22	3-1/2"	8-16
1-1/4"	11-22	3-3/4"	8-16
1-5/16"	11-20	4"	8-16
1-3/8"	11-20	4-1/4"	8-16
1-7/16"	11-20	4-1/2"	8-16
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1-9/16"	10-20	5"	8-16
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1/4"	.540	.088	.065
3/8"	.675	.091	.065
1/2"	.840	.109	.083
3/4"	1.050	.113	.083
1"	1.315	.133	.109
1-1/4"	1.660	.140	.109
1-1/2"	1.900	.145	.109
2"	2.375	.154	.109
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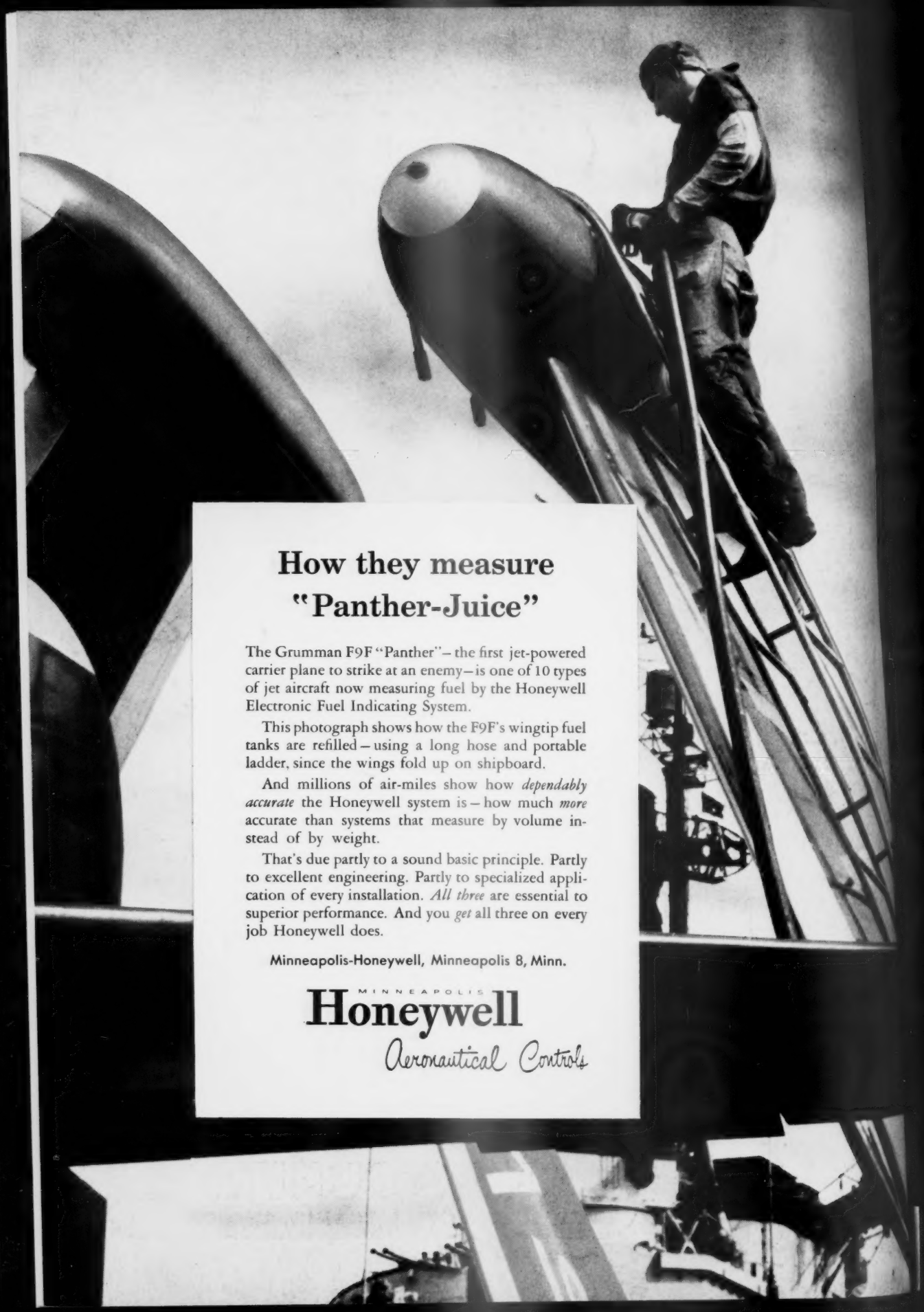

How they measure "Panther-Juice"

The Grumman F9F "Panther"—the first jet-powered carrier plane to strike at an enemy—is one of 10 types of jet aircraft now measuring fuel by the Honeywell Electronic Fuel Indicating System.

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